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78

ORIGINAL

ACCIDENT DATA ANALYSIS (SIDE IMPACT)

Prepared by

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Vehicle Research and Test Center
Washington, D.C. 20590

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16. Abstract

Beginning in 1976, the National Highway Traffic Safety Administration began collecting highway accident data under a study entitled the National Crash Severity Study (NCSS). This report describes the methodology for selecting potential "problem" side impact case reports from the NCSS file and the methodology for checking the cases. Cases which had grossly unexpected injury levels for a given collision severity level were reviewed. The velocity change which was mathematically calculated by the investigating team using the CRASH II computer model was checked for accuracy and corrected if in error. Common reasons for inaccurate reconstructions were summarized.

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

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INTRODUCTION

The basis for the goals in the National Highway Traffic Safety Administration's 5-year Rulemaking plan is real-world injuries. The extent and accuracy with which these injuries are understood depends upon the quality of accident investigation which the Agency is able to sponsor. In an effort to upgrade the quality of accident investigation the National Crash Severity Study (NCSS) was initiated in 1976. One of the primary goals of the study was to relate measures of crash severity to measures of crash occupant injury. The principle measures of crash severity used in the study are the impact velocities of the involved vehicles and the velocity change (Δv) of the vehicles. The occupant injuries are described in terms of a code called the Abbreviated Injury Scale.

Both intuition and results of earlier studies indicate that the injury severity increases with increased Δv. The probability of receiving a life-threatening or fatal injury at various Δv levels has been studied from earlier accident files. Preliminary checks of the data in the NCSS file indicated that the probability of life-threatening or fatal injury was lower than expected at higher levels of ΔV. This study was initiated to find out why.

BACKGROUND

The NCSS was formulated in an attempt to retrieve the most usable information in a reasonable time and for a reasonable cost. Seven accident investigation teams are employed in varying traffic use localities. Since injury producing accidents are of primary interest and occur less frequently, a sampling strategy was chosen which favored these accidents while maintaining representativeness of the sub population. The sampling scheme utilizes the information on the police report of the accident. Of all the accidents in which the police reported that no one was transported to the hospital,

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only 10 percent are sampled. If they were reported as treated and released then 25 percent are sampled. If they were admitted into the hospital at least over night then 100 percent are sampled. By adhering strictly to the sampling strategy, the study enables inferences back to the total population.

For each accident that is sampled, several types of data are gathered by the teams. As many as 12 separate report forms might be filled out for each case. Information is gathered from the police, the hospital, attending physicians, the vehicles, the accident scene, and occupants. The various report forms are summarized onto a Case Summary Report which is stored on a computer file. The information from the case summary is then the basis of all computer searches and retrieval. Appendix A contains the May 1977 version of the Case Summary Report form. During 1978, the summaries were expanded to include further information about the vehicles, the scene, and the occupants.

Figure 1 is the Collision Severity section of the Case Summary Report. The impact speed and delta "V" information is obtained through use of the CRASH II computer model. The CRASH II model was developed for the NHTSA by Calspan Corporation. It consists of a simple lumped mass approach utilizing energy and momentum relationships to give a closed form solution. Figure 2 is the Crash Program Summary page of the Case Summary Report. Data items 2 through 6 are the vehicle size, weight, and damage classification. Data items 9 through 33 are scene information and items 36 through 39 are vehicle damage details. If only data items 2 through 6 are known the CRASH II model has an algorithm to give a rough estimate of ΔV. If data items 36 through 39 are known in addition, the model uses another algorithm to more precisely calculate the ΔV. The impact velocities can be calculated only if data items 9 through 33 are obtained from the scene. Early indications from the NCSS showed that scene data is obtained in only approximately 25 percent of the cases.

DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY
ADMINISTRATION

NATIONAL CRASH SEVERITY STUDY: COLLISION SEVERITY

ACCIDENT IDENTIFICATION

1	___	UPDATE NUMBER
2	___	TEAM
3	___	YEAR
4-5	___ ___	MONTH
6-7	___ ___	DAY
8-10	___ ___ ___	SEQUENCE
11-13	___ ___ ___	CARD NUMBER

VEHICLE NUMBER ___ (14)

IMPACT WITH VEHICLE NO. ___ (15)

IMPACT NUMBER ___ (16)

IMPACT SPEED (MPH) ___ ___ (17 18)

DATA SOURCE (INPUT)		DELTA "V" MPH TOTAL			LONG. + -			LATERAL + -		
Trajectory & Detailed Damge	1									
Trajectory & CDC Only	2	19	20	21	22	23	24	25	26	27
Detailed Damage Only	3									
CDC Only	4									
Insufficient Data	9	28	29	30	31	32	33	34	35	36

RELATIVE VELOCITY: Longitudinal + - ___ ___ ___ ___ (37 38 39 40) MPH

Lateral + - ___ ___ ___ ___ (41 42 43 44) MPH

NOTE: Use Codes 1, 2 or 9 only in Column 19, and Codes 3, 4 or 9 only in Column 28.

VEHICLE NUMBER ___ (45)

IMPACT WITH VEHICLE NO. ___ (46)

IMPACT NO. ___ (47)

IMPACT SPEED (MPH) ___ ___ (48 49)

DATA SOURCE (INPUT)		DELTA "V" MPH TOTAL			LONG. + -			LATERAL + -		
Trajectory & Detailed Damage	1									
Trajectory & CDC Only	2	50	51	52	53	54	55	56	57	58
Detailed Damage Only	3									
CDC Only	4									
Insufficient Data	9	59	60	61	62	63	64	65	66	67

RELATIVE VELOCITY: Longitudinal + - ___ ___ ___ ___ (68 69 70 71) MPH

Lateral + - ___ ___ ___ ___ (72 73 74 75) MPH

NOTE: Use Codes 1, 2 or 9 only in Column 50, and Codes 3, 4 or 9 only in Column 59.

Figure 1 -- Collision Severity Summary Form

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DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

NATIONAL CRASH SEVERITY STUDY: CRASH PROGRAM SUMMARY

1 ACCIDENT IDENTIFICATION
- 1 UPDATE NUMBER ___
- 2 TEAM ___
- 3 YEAR ___
- 4-5 MONTH ___ ___
- 6-7 DAY ___ ___
- 8-10 SEQUENCE ___ ___ ___
- 11-13 CARD NUMBER ___ ___ ___

2 VEHICLE SIZE: #1___ #2___

3 CDC #1 ___ ___ ___ ___ ___ ___ ___

CDC #2 ___ ___ ___ ___ ___ ___ ___

4 WEIGHTS KNOWN
5 No - Go to 7
6 Yes - Wt. #1 ___ ___ ___ ___

Wt. #2 ___ ___ ___ ___

7 REST AND IMPACT POSITIONS KNOWN
8 No - Go to 34
9 Yes -
Veh. 1 X___ ___ ___.___
Y___ ___ ___.___
ϕ___ ___ ___ ___
Veh. 2 X___ ___ ___.___
Y___ ___ ___.___
ϕ___ ___ ___ ___

10 IMPACT POSITIONS
Veh. 1 X___ ___ ___.___
Y___ ___ ___.___
ϕ___ ___ ___ ___
Veh. 2 X___ ___ ___.___
Y___ ___ ___.___
ϕ___ ___ ___ ___

11 DID VEH. 1 SLIDE SIDEWAYS
12 No - Go to 16
13 Yes - Did rotation cease prior to final rest?
14 No - Go to 16
15 Yes - Location
X___ ___ ___.___
Y___ ___ ___.___
ϕ___ ___ ___ ___

16 WAS VEH. 1 PATH CURVED?
17 No - Go to 19
18 Yes - Point on Path
X___ ___ ___.___
Y___ ___ ___.___

19 VEHICLE #1 ROTATED?
20 None- Go to 22
21 CW or CCW (circle one)
More than 360° Yes No (circle one)

22 DID VEH. 2 SLIDE SIDEWAYS?
23 No - Go to 25
24 Yes - Did rotation cease prior to final rest?
No - Go to 25
Yes - Location
X___ ___ ___.___
Y___ ___ ___.___
ϕ___ ___ ___ ___

25 WAS VEH. 2 PATH CURVED?
26 No - Go to 28
27 Yes - Point on Path
X___ ___ ___.___
Y___ ___ ___.___

28 VEH. #2 ROTATED?
29 None - Go to 31
30 CW or CCW (circle one)
More than 360° Yes No (circle one)

31 COEFFICIENT OF FRICTION ___.___ ___

32 ROLLING RESISTANCE
33 1. Proportion Braking Each Wheel
Veh. 1 RF ___.___ ___
LF ___.___ ___
RR ___.___ ___
LR ___.___ ___
Veh. 2 RF ___.___ ___
LF ___.___ ___
RR ___.___ ___
LR ___.___ ___

OR

2. Longitudinal deceleration
Veh. 1 ___.___ ___
Veh. 2 ___.___ ___

34 ARE DAMAGE DIMENSIONS KNOWN?
35 No - Go to 37
36 Yes - Dimensions in Inches
Veh. 1 L ___ ___ ___ ___
C_1 ___ ___.___
C_2 ___ ___.___
C_3 ___ ___.___
C_4 ___ ___.___
C_5 ___ ___.___
C_6 ___ ___.___
D ± ___ ___ ___.___
Veh. 2 L ___ ___ ___.___
C_1 ___ ___.___
C_2 ___ ___ ___
C_3 ___ ___.___
C_4 ___ ___.___
C_5 ___ ___.___
C_6 ___ ___.___
D ± ___ ___ ___.___

37 IMPROVED FORCE DIRECTIONS?
38 No - Program Completed
39 Yes - Angles from Straight
Veh. 1 ± ___ ___ ___ ___
Veh. 2 ± ___ ___ ___ ___

Figure 2 -- Crash Program Summary Form

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In order to promote uniformity within the study and to enable checking of the data, a quality control contractor (Q.C.) is part of the study. The case reports from the teams are sent to the quality control center for review and coding of the data into the computer file. If improper or erroneous data is found in a case, the quality control center has the option of returning the case report to the accident team or of making the necessary edits to the report. In most instances, the control center edits the reports rather than returning them. Edits are made with a colored pencil to distinguish the edited value from the original team value.

Preliminary studies by the rulemaking personnel within the NHTSA subdivided the side impact cases in the NCSS file into categories according to the direction of force and the severity of the collision. The case report numbers that fell within each category were listed. It was decided that the 90° accident cases would be reviewed by the Highway Safety Research Institute as part of contract DOT-HS-8-01944 entitled, "Analysis of the National Crash Severity Study."

The remaining groups of side impact cases were to be sampled by the Safety Research Laboratory (SRL) to look specifically at the Δv and injury information. Table 1 is an early listing of the groups established for these side impact cases. At the request of Rulemaking personnel it was decided that groups 3, 4, and 8 were of primary importance and that the remaining groups were of a lesser priority. The procedure for obtaining the hard copy case reports was agreed upon at that time. All requests for cases were sent through the Accident Investigation Division of the National Center for Statistics and Analysis which has responsibility for the overall NCSS program. Directives were then given to the Q.C. contractor to send the desired cases to the SRL via air freight. At the completion of each segment of the study, the cases were returned via air freight to the Q.C. contractor. All significant findings were communicated to the NCSS and the Q.C. contractor as the study progressed.

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Figure 3 illustrates the type of cases that were selected for review. Regardless of the functional relationship that one chooses to fit through the injury vs. Δv data points it is still expected that injury increases with increase of ΔV. The bulk of the cases reviewed were those with AIS levels ≤ 3 and Δv levels > 23 mph. The arbitrary choosing of a Δv is not meant to imply that occupant injury is related only to the Δv of the vehicle. Table 2 is a list of some of the other factors that have been shown to be related to injury levels in side impact. In the case reviews for this study, the unexpected injury level at a given Δv level is often attributed to one or more of the other factors in Table 2.

Most of the cases requested were selected because of unexpected AIS levels for the Δv level of the accidents. The cases basically were found to be in one or more of the following categories:

Unusual cases reported accurately

Cases with coding errors

Cases with inaccurate Δv reconstructions.

An example of each of the categories will be given and then the specific findings of each group of cases will be outlined.

UNUSUAL CASES REPORTED ACCURATELY

Group 4 case 1709016 - The reported Δv was 25 mph from contact with a utility pole. The force direction determined by the team was 2 o'clock which should have thrown the R.F. occupant into the side door with substantial force. Only dashboard contact was noted for both front seat occupants and the injuries were minor. It was postulated that the occupants were thrown forward by precrash skidding and were against the dash at impact.

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TABLE 1

Rulemaking NCSS Case Categories

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8	Group 9	Group 10	Group 11
High ΔV-Low AIS PDOF 7&11	High ΔV-Low AIS PDOF 10	High ΔV-Low AIS PDOF 8&10	High ΔV-Low AIS Low ΔV-High AIS PDOF 2&4	High ΔV-Low AIS Low ΔV-High AIS PDOF 1,5&11	Low ΔV-High AIS PDOF 8&10	High ΔV-High AIS PDOF 2&4	High ΔV-High AIS PDOF 7,8 10&11	Low ΔV-Low AIS PDOF 1,2&4	Low ΔV-Low AIS PDOF 7,8 10&11	PDOF 3&9
Case #	Case #	Case #	Case #	Case #	Case #	Case #	Case #	Case #	Case #	Case #
3711031	1702027	1712035	1709016	1707005	4702038	1703002	3705005	6710028	3705054	4703020
1706033	1803001	1712049	3703017	1711023	4706047	1706028	6706034	1705030	1701084	5703027
1708053	3702015	2703026	4709046	4702031	2707030	1803028	1708022	1707017	1709015	5706007
1709017	3705023	5702060	5802026	4709048	2709023	2703038	3710045	1711034	1704046	6706009
1711062	3706048	5707033	6709100	5706031	4708041	3709066	1703006	1705013	1802012	7705008
1801056	3711039	5710030	1712033	6709062	4708049	3712062	1803008	4708009	1802040	1701008
1802049	4703021	6704019	6707007	6710007	5710040	4705045	4710010	5706050	1802042	6801084
2709022	4705024	6709039	1702036	6801046	3712037	1707062	6704066	6702023	1803056	3704015
2711028	5704010	6709087		1702040	5705060	1709050	6708036	6802016	2709012	6706043
3706033	5705068	6709104		4712040	5708025			6703090	2711005	5705050
3710060	5707012	6711005		1707039	2712001			6707062	4710003	
4709023	6708060	6711014			3704027				5701078	
4711028	6710049	6801038			6801077				5701080	
5702034	6711099	1709012			5703060				5802067	
6706111	5701067	4703043							6802042	
6710046		3704044							6803077	
6711018									1711015	
6803078									5701028	

Table 1 - Rulemaking NCSS Case Categories

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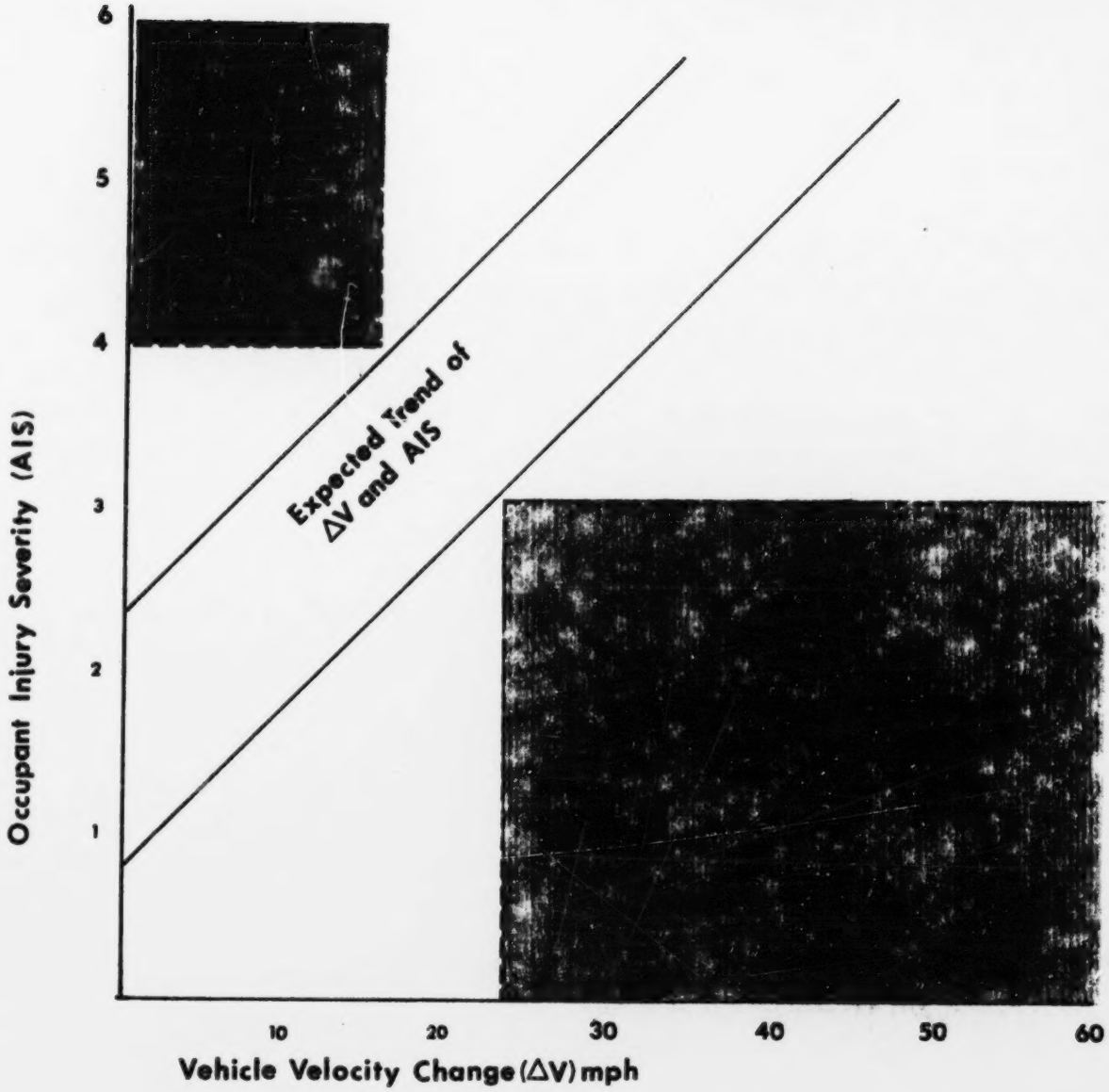

Figure 3—Expected Trends and Areas of Case Examination

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TABLE 2

Parameters Influencing Side Impact AIS Rating

Occupant Location (Far Side Near Side)
Ejection from Vehicle
Occupant Age
Seat Belt Useage
Vehicle Size

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Group 4 Case 1712033 - This case had a reported Δv of 6 mph and an injury level of AIS=3. The injury as noted was 2 fractured ribs. No errors were noted in the reporting and the reason for rib fractures in such a minor noncompartment impact was not known.

CASES WITH CODING ERRORS

Group 8 Case 1803008 - This case was reported as a 23 mph Δv and the driver of the car receiving AIS level 5 chest and abdomen injuries. the impact was with a truck which was coded as having a Δv of 38 mph. It was apparent that the car Δv and truck Δv were reversed and that the 38 mph Δv was that of the car.

CASES WITH INACCURATE ΔV RECONSTRUCTIONS

Group 3 Case 6711014 - This case was coded as a 47 mph Δv and the driver injury was only minor (AIS=1). The Δv computed by the SRL was 23 mph. The error was due to the team's using induced damage instead of direct contact damage and also due to incorrect force directions and damage offset length. The last two items were noted by the Q.C. contractor but the faulty reconstruction had not been corrected.

Group 4 Case 5802026 - The case was reported as a 20 mph Δv and the injury level was minor (AIS=1). The slides showed that the reference line used by the team to measure the amount of crush was placed at the mid-door elevation while the crush was at the sill level. Only a slight difference was noted when the correction was made. The SRL Δv was 18 mph.

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The most common types of reconstruction errors are summarized as follows:

Improper force direction coded by team. (These were nearly always corrected by the Q.C. contractor but the Δv reconstruction was not always corrected accordingly.)

Induced damage included in the "L" dimension (the length of the damage region).

Clerical errors in transferring the vehicle data from the other forms to the Crash Program Summary form.

Incorrect reference line for crush measurements (see Figure 4).

Missing crush measurements for impact vehicle (unable to locate or repaired before located, etc.) and unreasonable crush measurements assumed.

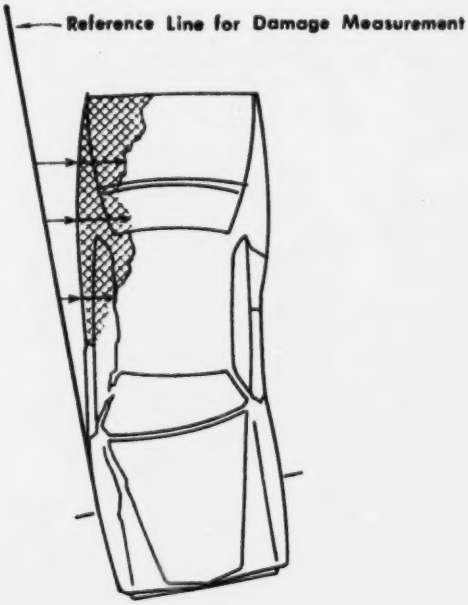

Figure 4 — Damage Reference Line

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SPECIFIC FINDINGS OF EACH GROUP OF CASES

The cases of group 3 in Table 1 were the first to be reviewed. (Group 3 is a high Δv low AIS category.) One of the 16 cases received turned out to be the wrong case so only 15 were analyzed from this group. Of the 15 cases, 7 were found to have incorrect Δv levels due to improper reconstruction techniques. Another case was found to have serious coding inconsistencies and no reconstruction could be performed at the SRL. The remaining 7 cases appeared to be accurately reported. Table B-1 in Appendix B contains a summary of the case findings of group 3. The reader should bear in mind that this and other samples were selected by the SRL because they appeared to have problems. The percentage of these cases with errors should not be assumed representative of the overall file.

The group 8 (predominantly side swipe with high injury) cases were next reviewed. It is believed that any side swipe collision is difficult to reconstruct with the Crash II model. This is due to the requirement that a common velocity be achieved between the vehicles in order for a momentum balance approach to be valid. In two of the 8 cases, it was doubtful that a common velocity was actually achieved. Two other reconstructions were found to be in error. For another case, the ΔV's were reversed on the form so that the case vehicle was coded as having a lower Δv than the impacting truck. The summary of the cases in group 8 is in Table B-2.

The cases of group 4 were the final ones to be reviewed out of the Table 1 listing. This small group of 8 cases contained both low Δv with high AIS and high Δv with low AIS. When the cases arrived at the SRL it was found that the ΔV's for 4 of the cases had recently been altered as part of the Q.C. checking procedures. The SRL was in agreement with the new Δv values in each of the 4 cases. Of the remaining 4 cases, 1 was found to be in error and the changes made only a slight (2 mph) difference in the ΔV. The summary of the group 4 cases is shown in Table B-3. The case by case review notes of groups 3, 4, and 8 are contained in Appendix B.

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In total, 31 case reports were reviewed from the Table 1 listing. Since they were selected mostly from an injury-ΔV standpoint (except group 8 which were all high Δv and high injury) it is interesting to plot the injury vs Δv relationships before and after the SRL review. Figure 5 is a plot of the 31 accidents ΔV-AIS correlations as reported on the NCSS summary file before the SRL review. Figure 6 shows the same data after the review.

Following the case review of the groups on Table 1, the SRL was requested to review the 90° cases from the file. A listing of all 3 o'clock and 9 o'clock force direction cases was dumped from the summary tape along with velocity and injury data. Thirty-five cases were selected for review for various reasons and the case numbers are listed in Table 3. Of the 35 cases requested, 30 were received and reviewed by the SRL. Eight of the 30 cases were found to have insufficient or unsuitable data and should not have been reconstructed by the team. The SRL recommended that the ΔV's from these cases be dropped from the summary file and coded as unknown. An additional 8 cases were found to have errors in the reconstructions and these were reconstructed at the SRL and the ΔV's altered accordingly. Figures 7 and 8 are plots of the ΔV-AIS correlations before and after the SRL review. Since many of the requested cases had unknown injury severities, they are not shown on the plots. Table 4 is a listing of the AIS and Δv information for the 90° cases that were reviewed. The case by case review notes are contained in Appendix C.

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TABLE 3

CASES REQUESTED FOR SRL REVIEW

Case No.	Delta-V Tot.	AIS	Case No.	Delta-V Tot.	AIS
1701008	12	4	7705009	25	8
1708025	12	2	7712036	19	8
1711047	24	8	1711025	24	9
2705025	37	9	1803031	7	2
2707019	11	5	1803049	29	1
2712024	7	8	2702022	26	2
3704016	22	3	4701006	27	2
3707074	3	3	4702045	16	8
3708036	22	1	4703015	23	2
3711034	23	8	4708042	18	9
5702007	17	9	6702099	36	8
5705050	20	1	6706038	13	0
6706012	19	0	7701011	27	8
6706037	8	0	7705008	30	5
6708021	10	0	1709009	11	1
6709010	24	8	1707039	7	5
6711078	18	0	6708016	19	8
7702005	15	8			

BEST DOCUMENT AVAILABLE

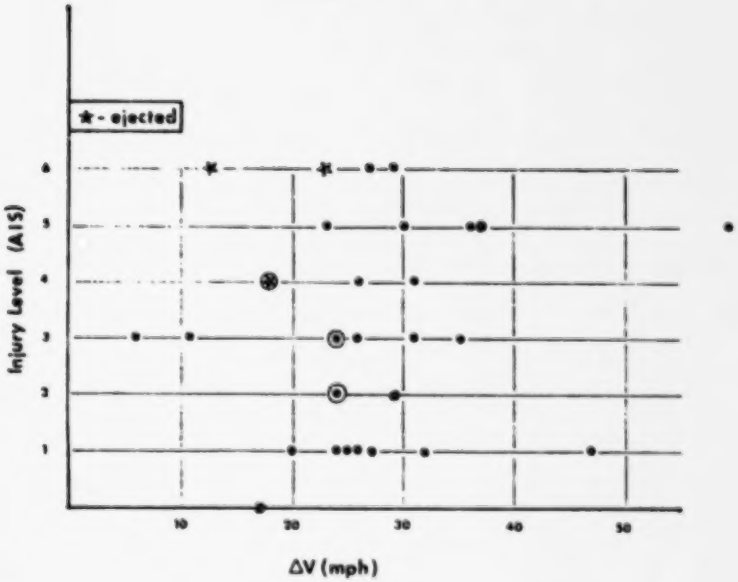

Figure 5 —— ΔV-AIS Data Groups 3, 8, and 4 Before SRL Review

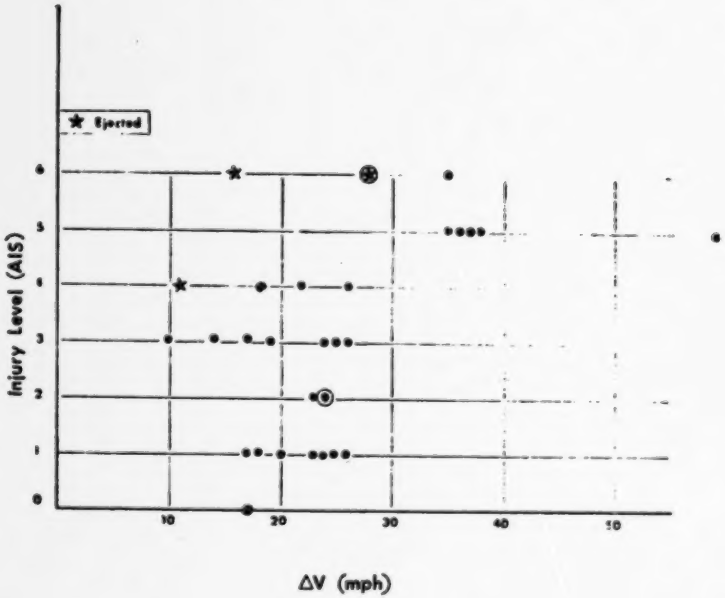

Figure 6 —— ΔV-AIS Data Groups 3, 8 and 4 After SRL Review

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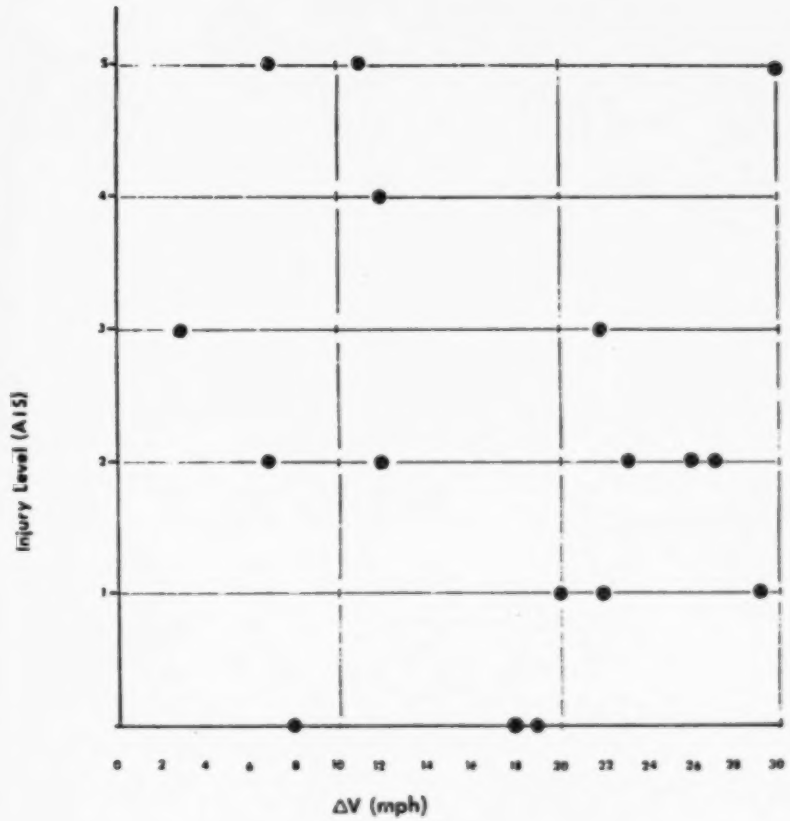

Figure 7——ΔV-AIS Data 90° Cases Before SRL Review

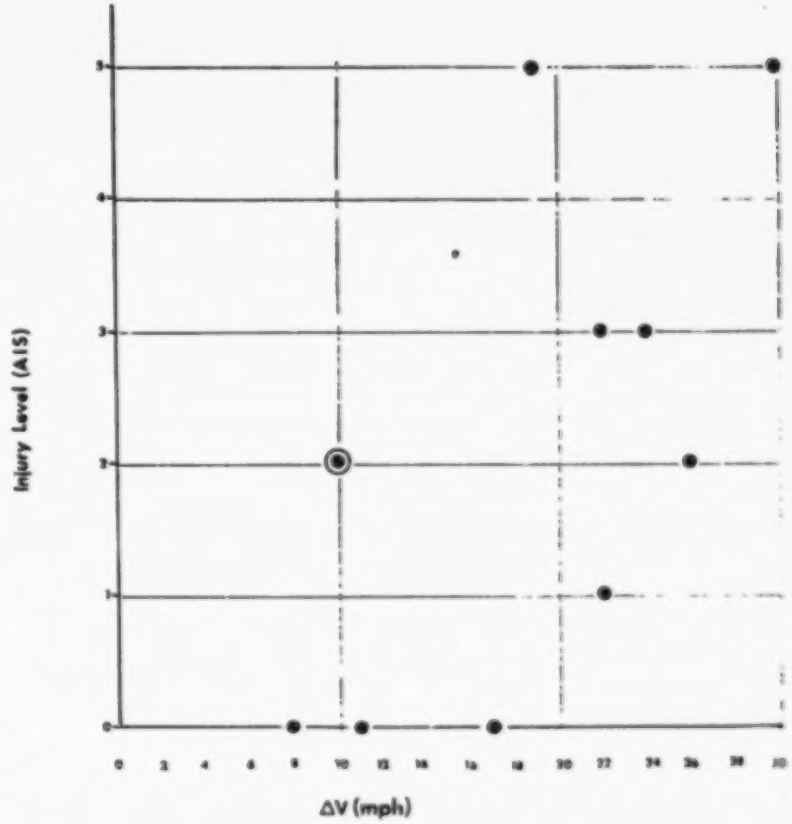

Figure 8——ΔV-AIS Data 90° Cases After SRL Review

TABLE 4 **BEST DOCUMENT AVAILABLE**

SUMMARY OF CASE REVIEWS

	File Data		SRL Review Results	
NCSS Case No.	ΔV (mph)	AIS	ΔV	AIS
1711025	24	9	10	9
2707019	11	5	19	5
2712024	7	8	3	8
3708036	22	1	22	1
6706037	8	0	8	0
6711078	18	0	17	0
6706012	19	0	11	0
6709010	24	9	24	3
7702005	15	8	15	8
1701008	12	4	DROP	
1707039	7	5	DROP	
1803049	29	1	DROP	
2705025	37	9	14	9
3704016	22	3	22	3
3707074	3	3	DROP	
4701006	27	2	10	2
4703015	23	2	DROP	
7712036	19	8	DROP	
7705008	30	5	30	5
5702007	17	9	10	9
7705009	25	8	25	9
4702045	16	8	16	8
5705050	20	1	DROP	
6702099	36	8	14	8
7701011	27	8	27	8
1708025	12	2	DROP	
1711047	24	8	24	8
1803031	7	2	10	2
2702022	26	2	26	2
4708042	18	9	11	9

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DEVELOPMENT OF RELATIVE VELOCITY CALCULATION

A second portion of this project was to develop a method of calculating the relative velocity between the impacting vehicles. The reason for calculating the relative velocity for accidents is to aid the rulemaking engineer in determining the test conditions for safety compliance testing. Ideally, if the impact velocities were known for each accident, then a test condition could easily be selected as a representative combination of vehicle speeds in the side-impact mode. As has been pointed out, only about 25 percent of the accident cases have sufficient scene data to compute the impact velocities. The bulk of the cases only have data appropriate for calculating the Δv of each vehicle. If one were to choose a Δv condition as the sole severity requirement for a compliance test, the burden would be on the test engineer to predict the pre-impact conditions which would cause the desired Δv response. If, however, the relative velocity were known as additional information, the test set-up can more reasonably be accomplished. This presentation is intended to demonstrate how the relative velocity of an impact can be obtained from the information already available as input to the CRASH II model.

The term "relative velocity" in this text shall mean the vector subtraction of the impacting vehicle velocity and the struck vehicle velocity, or

$$\bar{V}_r = \bar{V}_1 - \bar{V}_2$$

where

$\bar{V}_1$ = velocity vector of the impacting vehicle

$\bar{V}_2$ = velocity vector of the side struck vehicle

and $\bar{V}_r$ = relative velocity vector

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Figure 9 shows two vehicles at the moment of impact with the corresponding velocity vector diagram.

The concept of relative velocity can be derived from the momentum conservation equations. Specifically, for a plastic collision,

$$M_1\bar{V}_1 + M_2\bar{V}_2 = (M_1 + M_2)\,\bar{V}_f \qquad \text{(eq. 1) conservation of momentum}$$

and

$$M_2\bar{V}_1 = M_2\bar{V}_1 \qquad \text{(eq. 2) identity}$$

adding eq's 1 and 2

$$M_1\bar{V}_1 + M_2\bar{V}_2 + M_2\bar{V}_1 = (M_1 + M_2)\,\bar{V}_f + M_2\bar{V}_1 \qquad \text{(eq. 3)}$$

collecting terms

$$(M_1 + M_2)\,\bar{V}_1 + M_2\bar{V}_2 = (M_1 + M_2)\,\bar{V}_f + M_2\bar{V}_1 \qquad \text{(eq. 4)}$$

$$(M_1 + M_2)\,(\bar{V}_1 - \bar{V}_f) = M_2\,(\bar{V}_1 - \bar{V}_2) \qquad \text{(eq. 5)}$$

and

$$\bar{V}_1 - \bar{V}_f = \frac{M_2}{M_1 + M_2}\,(\bar{V}_1 - \bar{V}_2)$$

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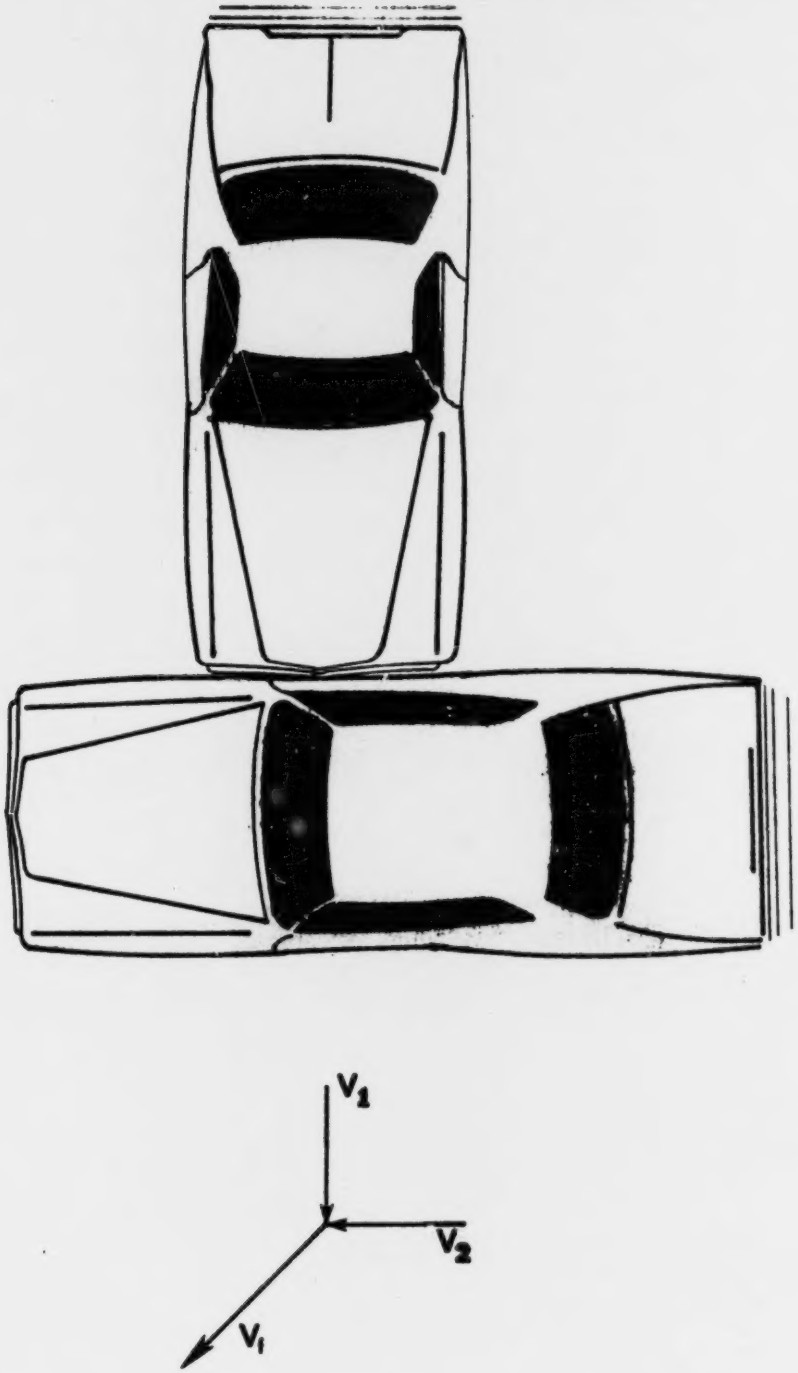

Figure 9 — Impact Velocity Vector Diagram

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Let

$$\bar{V}_1 - \bar{V}_2 = \bar{V}_r \qquad \text{(eq. 7) definition}$$

$$\bar{V}_1 - \bar{V}_f = -\Delta\bar{V}_1 \qquad \text{(eq. 8) definition}$$

$$\Delta\bar{V}_1 = \left(\frac{-M_2}{M_1 + M_2} \right) \bar{V}_r \qquad \text{(eq. 9)}$$

In the same manner, it can be shown that

$$\Delta\bar{V}_2 = \left(\frac{M_1}{M_1 + M_2} \right) \bar{V}_r \qquad \text{(eq. 10)}$$

Equations 9 and 10 illustrate that the delta-V's occur in the direction of the relative velocity vector.

Thus, the concept of delta-V as used in accident reconstruction is coupled with that of the relative velocity as eq's 9 and 10 show.

To further illustrate this concept, examine Figure 10 which is a two dimensional plastic collision. The vector diagram shows that

$$\bar{V}_r = \Delta\bar{V}_2 - \Delta\bar{V}_1 \qquad \text{(eq. 11)}$$

BEST DOCUMENT AVAILABLE

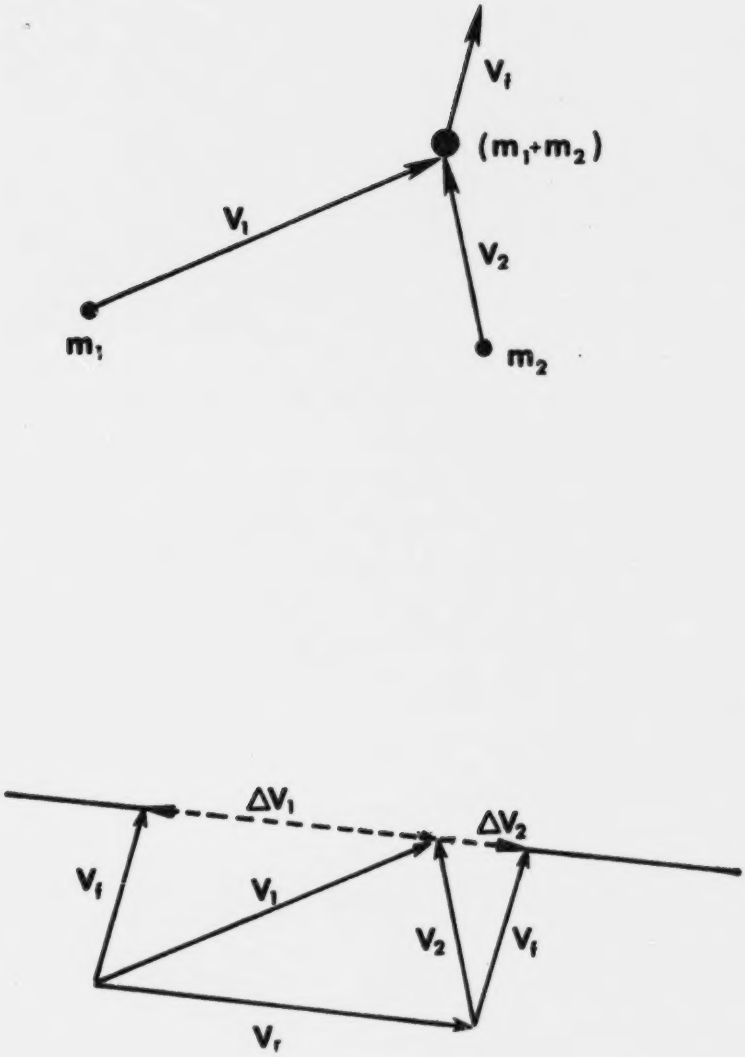

Figure 10—Velocity Change Vector Diagram

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This equation illustrates that for plastic collision (1) the delta-V's occur in the direction of the relative velocity vector, (2) the final velocity is common to each mass in magnitude and direction, and (3) the vector addition of the delta-V's is equal to the relative velocity. From Figure 10, the magnitude of the relative velocity vector can be determined if the magnitude of the two delta-V's are known, specifically

$$|\Delta\bar{V}_1| + |\Delta\bar{V}_2| = |\bar{V}_r| \qquad \text{(eq. 12)}$$

An examination of the computer code CRASH II illustrates a similar development with one major difference. Specifically, the change in computed total energy due to "rotation during impact". Because of this rotational inertia, the sum of the delta-V's computed by the CRASH II program is less than the relative velocity whenever rotation occurs.

The basic equations for computing delta-V's in the model for centrally aligned cases is:[1]

$$\Delta V_1 = \sqrt{\frac{2(E_1 + E_2)}{M_1 \left(1 + \frac{M_1}{M_2}\right)}} \qquad \text{(eq. 13)}$$

$$\Delta V_2 = \sqrt{\frac{2(E_1 + E_2)}{M_2 \left(1 + \frac{M_2}{M_1}\right)}} \qquad \text{(eq. 14)}$$

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For non-central collisions, the equations become:

$$\Delta V_1 = \sqrt{\frac{2\gamma_1 (E_1 + E_2)}{M_1 \left(1 + \frac{\gamma_1 M_1}{\gamma_2 M_2}\right)}} \qquad \text{(eq. 15)}$$

$$\Delta V_2 = \sqrt{\frac{2\gamma_2 (E_1 + E_2)}{M_2 \left(1 + \frac{\gamma_2 M_2}{\gamma_1 M_1}\right)}} \qquad \text{(eq. 16)}$$

where

E_1 = Energy to crush V_1

E_2 = Energy to crush V_2

M_1 = Mass of V_1

M_2 = Mass of V_1

$$\gamma_1 = \frac{k_1^2}{k_1^2 + h_1^2}$$

k_1 = radius of gyration of V_1

h_1 = moment arm of force application on V_1

[1]for derivation see DOT-HS-801 838 page 54-56

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Equations 13 and 14 are identically equal to equations 15 and 16 when $h_1 = h_2 = 0$. Also, when $h_1 = h_2 = 0$, the linear momentum is conserved and the sum of the delta-V's is equal to V_r. Thus, a slight change in the model (computing two sets of delta-V's, once with $h_1 = h_2 = 0$ and once with h_1 = moment arm V_1 and h_2 = moment arm V_2) would enable both the correct delta-V calculation and the correct relative velocity calculation.

The procedure would be the following:

Step 1 - set h_1 = moment arm of force of V_1

h_2 = moment arm of force on V_2

calculate delta-V_1 and delta-V_2
(these are the actual delta-V's)

Step 2 - set $h_1 = h_2 = 0$

calculate delta-V_1 and delta-V_2

then $V_r = \Delta V_1 + \Delta V_2$

The above procedure is useful for future cases but it may not be the most economic way to estimate the relative velocity for the hundreds of side impact cases already on the file. A specialized routine could be developed especially for side impacts to calculate relative velocities for all the cases which already have delta-V's. Such a procedure would consist of the "heart" of the CRASH II model and would eliminate many of the decision points and checking, etc. of the CRASH II code.

The SRL developed an interactive computer code to demonstrate the methodology for calculating the relative velocities. (See Appendix D for a copy of the code).

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(The output parameters of the model are the new delta-V's (calculated with $h_1 = h_2 = 0$) and the relative velocity. These delta-V's are higher than those computed by the CRASH II model.)

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are given as a result of this study:

The cases with grossly unexpected ΔV-AIS relationships should be carefully double checked by the Quality Control Center for reconstruction and coding errors.

High injury (AIS 3) and/or high Δv cases should routinely be double checked for accuracy.

The relative velocity should be computed via an automated procedure for all cases presently on the NCSS file.

A relative velocity calculation routine should be added to future CRASH II accident reconstructions.

It is concluded that in sampling the cases that appeared questionable from a ΔV-AIS standpoint, a high percentage were found to have reconstruction errors. No conclusions can be drawn as to the quality of data in a random file sampling.

The obvious conclusion that one would like to see from the study is regarding the quality of the data presently being collected in the NCSS and how well the Quality Control Center is performing its duty. It was intended that each batch of cases would receive the routine Quality Control check before being sent to the SRL for review. However, it turned out each time that Q.C. still had intended further changes after the cases were shipped to the SRL. Since the cases were not in their final form, no conclusions could be drawn about the Quality Control efforts on the cases.

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REFERENCES

(1) Burgett, A. L., and Monk, M. W., "Car-to-Car Side Impacts: Computerized Crash Reconstruction, U.S.D.O.T., NHTSA.

(2) HSRI, "Analysis of NCSS Side Impact Cases, University of Michigan, March 1979.

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APPENDIX A

BEST DOCUMENT AVAILABL

CASE SUMMARY REPORT

DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

NATIONAL CRASH SEVERITY STUDY: GENERAL ACCIDENT DATA

ACCIDENT IDENTIFICATION

1	__	UPDATE NUMBER
2	__	TEAM
3	__	YEAR
4-5	__ __	MONTH
6-7	__ __	DAY
8-10	__ __ __	SEQUENCE
11-13	0 0 0	GENERAL
14-16	__ __ __	COUNTY
17-20	__ __ __ __	JURISDICTION
21-22	__ __	REPORTED BY

NOTE: Where codes are listed, they may be circled or inserted on the lines provided throughout this form.

SAMPLE CONTROL

23 __ ACCIDENT SEVERITY

1 Fatal
2 Injury - Overnite Hosp.
3 Injury - Transported
4 No Transport

24 __ SAMPLING FRACTION

1 All Cases (100%)
2 One of Four (25%)
3 One of Ten (10%)

REPORTS SUBMITTED

25	__	Police
26	__	Environmental
27	__	Off-Road Object
28	__	Vehicle
29	__	Side Structure
30	__	Pass. Comp. Intrusion
31	__	Seat Performance
32	__	Fire
33	__	Rollover
34	__	Interview
35	__	Medical
36	__	Surgical Procedures

37 __ NUMBER OF VEHICLES INVOLVED
1-7 = Total No. of Vehicles
8 = 8 or More
9 = Unknown

NUMBER OF PEOPLE INVOLVED

38-39	__ __	Total	Actual No. = 01-9
40-41	__ __	Injured	98 or More = 98 Unknown = 99
42-43	__ __	Fatal	

44 __ NUMBER OF CASE VEHS. INVOLVE
1-7 = Actual No. of Case Veh
8 = 8 or More
9 = Unknown

NUMBER OF PEOPLE INVOLVED (CASE CARS)

45-46	__ __	Total	Actual No. = 01-9
47-48	__ __	Injured	98 or More = 98 Unknown = 99
49-50	__ __	Fatal	

GENERAL DATA

51-52 __ __ TIME OF DAY

53 __ ROAD CONDITION
1 Dry
2 Wet
3 Ice
4 Snow
5 Other Condition
9 Unknown

54 __ INTERSECTION
0 None
1 3 leg T
2 3 leg Y
3 4 leg cross
4 4 leg oblique
5 Multileg
9 Unknown

55 __ RURAL - URBAN
1 Rural
2 Urban
9 Unknown

ACCIDENT DESCRIPTION

56-57 __ __ TYPE OF IMPACT

00	No Impact	
01	Car/Veh.:	Head-On
02		Angle Frontal
03		Side
04		Angle Side
05		Rear
06	Car/Fixed Object:	Front
07		Side
08		Rear
09	Car/Other Object	
10	Principal Rollover	
11	Sideswipe	
12	Undercarriage	
13	3 or More Vehicles - Ch	
14	3 or More Vehicles - Ot	
99	Unknown	

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NATIONAL CRASH SEVERITY STUDY: GENERAL ACCIDENT DATA (Page 2)

VEHICLE

58-63

#1	#2	#3	VEHICLE MANEUVER
			Driver Controlled
01	01	01	Going Straight
02	02	02	Right Turn
03	03	03	Left Turn
04	04	04	U-Turn
05	05	05	Changing Lanes
06	06	06	Passing
07	07	07	Straight, Slowing
08	08	08	Backing
09	09	09	Stopped in Traffic
10	10	10	None: Double Parked
11	11	11	None: Parked, Not in Traffic
12	12	12	Parking
13	13	13	Leaving Parked Position
14	14	14	Starting in Roadway
15	15	15	Exiting Private Roadway
			Not Driver Controlled
21	21	21	Sliding, Leading with: Front
22	22	22	Right
23	23	23	Left
24	24	24	Rear
25	25	25	Rotating: Clockwise
26	26	26	Counterclockwise
97	97	97	Other
	98	98	Not Applicable
99	99	99	Unknown

APPROACH DESCRIPTION

64-66

			FUNCTIONAL CLASSIFICATION	
0	0	0	Arterial Highway	Principal Arterials
1	1	1	Expressway	
2	2	2	Freeway	
3	3	3	Minor Arterials - Major Street/Highway	
4	4	4	Collector - Through Street/ Highway	
5	5	5	Local Street/Road	
7	7	7	Other	
8	8	8	Not Applicable	
9	9	9	Unknown	

VEHICLE

67-72

#1	#2	#3	ALIGNMENT	
01	01	01	Level	Straight
02	02	02	Uphill	
03	03	03	Downhill	
04	04	04	Crest of Hill	
05	05	05	Bottom of Hill	
06	06	06	Level	Curve Right
07	07	07	Uphill	
08	08	08	Downhill	
09	09	09	Crest of Hill	
10	10	10	Bottom of Hill	
11	11	11	Level	Curve Left
12	12	12	Uphill	
13	13	13	Downhill	
14	14	14	Crest of Hill	
15	15	15	Bottom of Hill	
98	98	98	Not Applicable	
99	99	99	Unknown	

73-75

			SURFACE TYPE
1	1	1	P.C. Concrete
2	2	2	Bituminous
3	3	3	Brick, block
4	4	4	Slag, stone, shell, gravel
5	5	5	Other
6	6	6	Dirt
8	8	8	Not Applicable
9	9	9	Unknown

76-78

			SPEED LIMIT
0	0	0	None (parking lot or other off-road)
1	1	1	20 MPH (or less)
2	2	2	25
3	3	3	30
4	4	4	35
5	5	5	40
6	6	6	45
7	7	7	50
8	8	8	55
9	9	9	Unknown or NA

79

1	Completed: Damage & Traj.
2	Damage Only
	Unable to Complete:
3	Rollover
4	Vaulting

CRASH RECONSTRUCTION

5	Other Non.-Horizontal Force
6	Insufficient Data
7	Skidding Sideways
8	Yielding Fixed Object
9	Other

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DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

NATIONAL CRASH SEVERITY STUDY: VEHICLE DATA

(Complete this page for all vehicles in accident)

ACC. IDENTIFICATION

1	__	UPDATE NUMBER
2	__	TEAM
3	__	YEAR
4-5	__ __	MONTH
6-7	__ __	DAY
8-10	__ __ __	SEQUENCE
11-13	__ __ __	VEHICLE NUMBER
14-15	__ __	NO. OF VIN CHARAC.
16-22	__ __ __ __ __ __ __	VIN
23-27		MAKE/MODEL:
	__ __ __ __ __	Code
	_____	Write In
28-32	__ __ __ __ __	ODOMETER
33-34	__ __	MODEL YEAR (last two digits)

35-36 __ __ BODY STYLE:

AUTOMOBILES
- 01 Passenger Car
- 02 Stationwagon
- 03 Convertible
- 04 Car, Pickup Body

TRUCKS
- 05 Van - passenger
- 06 - cargo
- 07 Multipurpose
- 08 Pickup
- 09 Straight Truck
- 10 Tractor Trailer

OTHER
- 11 School Bus
- 12 Other Bus
- 13 Motorcycle
- 98 Other Body Style
- 99 Unknown

VEHICLE WEIGHT
(To nearest 100 lbs.)

37-39	__ __ __	Vehicle Weight
40-42	__ __ __	Occ. & Cargo Only

43 __ TOWING ANOTHER VEH.
- 1 Yes
- 2 No
- 9 Unknown

44-65 VEHICLE DAMAGE

	Object Contacted	CDC					Veh. #	Imp. #
(1)	44 45	46 47	48	49	50	51	52	53	54
(2)	55 56	57 58	59	60	61	62	63	64	65

(1)=Highest Severity (ΔV)

66 __ VEHICLE TOWED FROM SCENE
- 1 Yes
- 2 No
- 9 Unknown

67 __ SOURCE OF VEHICLE DATA
- 1 Inspection at repair or tow facility
- 2 Inspection at person's home
- 3 Inspection at scene
- 4 Not Inspected. (Photos or repair data)
- 5 Not Inspected. Reason: ____
- 9 Unknown

68 __ VEH. INSPECTION BY INVESTIGATOR
- 0 Not Inspected
- 1 Inspected on first visit
- 2, 3, 4, 5, 6, 7 Actual number of locations visited (including follow-ups to same location)
- 8 8 or More
- 9 Unknown

69 __ APPLICABLE VEHICLE
- 1 Yes
- 2 No

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NATIONAL CRASH SEVERITY STUDY: VEHICLE DATA (Page 2)

(Complete this page only for applicable cars)

70 __ FRONT SEAT TYPE
- 1 Bench
- 2 Split-Bench
- 3 Bucket
- 8 Other
- 9 Unknown

71 __ HEAD RESTRAINTS
- 0 None
- 1 Integral
- 2 Adjustable: Left Side Only
- 3 Right Side Only
- 4 Both Sides
- 5 Add-On: Left Side Only
- 6 Right Side Only
- 7 Both Sides
- 8 Other
- 9 Unknown

MEASUREMENT, TOP OF SEAT CUSHION TO TOP OF HEAD RESTRAINT (INCHES)

72-73 __ __ LF
74-75 __ __ RF

No Restraint = 00
Actual Measure = 01-97
Unknown = 99

SIDE STRUCTURE PERFORMANCE

76 __ DOOR OPENING
- 0 None
- 1 LF
- 2 RF
- 3 LR
- 4 RR
- 5 LF & RF
- 6 LF & LR
- 7 RF & RR
- 8 Other Combinations
- 9 Unknown

77 __ LATCH OR HINGE DAMAGE
- 0 None
- 1 LF
- 2 RF
- 3 LR
- 4 RR
- 5 LF & RF
- 6 LF & LR
- 7 RF & RR
- 8 Other Combinations
- 9 Unknown

78 __ INTRUSION
- 0 None
- 1 Steering Column
- 2 A-Pillar
- 3 Steering Column and A-Pillar
- 4 Side
- 5 Side, with sill override
- 6 Roof
- 7 Rear-end
- 8 Other Area Combinations
- 9 Unknown

COMMENTS (Describe latch damage and intrusion damage): _____

_____

_____

_____

_____

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DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY
ADMINISTRATION

NATIONAL CRASH SEVERITY STUDY: OCCUPANT DATA

ACCIDENT IDENTIFICATION

1 __ UPDATE NUMBER
2 __ TEAM
3 __ YEAR
4-5 __ __ MONTH
6-7 __ __ DAY
8-10 __ __ __ SEQUENCE
11-13 __ __ __ OCCUPANT NUMBER

POSITION IN VEHICLE

14 __
1 Seat Area: Front
2 Second
3 Third
4 Other
9 Unknown

15 __
1 Location - On Seat: Left
2 Center
3 Right
4 Entire
5 On Floor: Left
6 Center
7 Right
8 Entire
9 Unknown

OCCUPANT DESCRIPTORS

16-17 __ __ AGE: 00 - less than one year
01-97 - actual age
98 - 98 and older
99 - Unknown

18-19 __ __ HEIGHT (INCHES) to 98 - actual height
99 - Not Reported

20-22 __ __ __ WEIGHT (LBS.) to 998 - actual weight
999 - Not Reported

23 __ SEX:
1 Male
2 Female
3 Female, pregnant
4 Female, Unk. if pregnant
9 Unknown

24-26 __ __ __ **RESTRAINT USE**

POLICE	INTERVIEWER	INVESTIGATOR	
0	0	0	Not Used
1	1	1	Lap & Torso
2	2	2	Lap Only
3	3	3	Torso Only
4	4	4	Air Cushion & Lap
5	5	5	Air Cushion
6	6	6	Passive Belt
7	7	7	Child Seat
8	8	8	No Restraint
9	9	9	Unknown

27 __ **INJURY SEVERITY (POLICE RATING)**
1 K Killed
2 A Incapacitated
3 B Not Incapacitated
4 C Possible Injury
5 O Not Injured
9 Unknown

28 __ **EJECTION - ENTRAPMENT**
0 None
1 Complete Ejection
2 Partial Ejection
3 Partial Ejection & Trapped
4 Ejection, Unknown Degree
5 Trapped
6 Other
9 Unknown

29-30 __ __ **EJECTION AREA**

	LF	RF	LR	RR	REAR	UNK.
No Ejection	00					
Window						
Open	01	02	03	04	05	09
Closed, dam.	11	12	13	14	15	19
Unk. if open	21	22	23	24	25	29
Door	31	32	33	34	35	39
Windshield:						
Bond Sep.	40					
Not Sep.	41					
Roof (convrt. or sunroof)	50					
Other	60					
Unk. Ej. Site	98					
Unk. if Ej.	99					

31 __ **NCSS CLASSIFICATION**
1 Fatal - Autopsy Obtained
2 Fatal - Medical Diagnosis
3 Fatal - Not Documented
4 Non-Fatal - Overnight Hospitalization
5 Non-Fatal - Transported & Released
6 Other Treatment
7 Treatment Unknown - Not transported
8 No Treatment - Not Transported
9 Unknown

PATIENT HISTORY

32 __ **OUTPATIENT VISITS**
0 = None
1-6 = Actual Number
7 = 7 or More
8 = Not Injured
9 = Unknown

ACTIVITY RESTRICTION (DAYS)

33-34 __ __ Bed Rest
35-36 __ __ Other Restriction
37-38 __ __ Work Days Lost
39-40 __ __ Days in Hospital

SEE MANUAL FOR CODES USED IN COLUMNS 33-40

41 __ **NECK INJURY (Rear & Rear Corner Impacts, 4-8 o'clock)**
Whiplash Symptoms Appeared:
0 = Immediately
1-6 = Actual Days Later
7 = 7 or More
8 = Not Applicable
9 = Unknown

42 __ **INTERVIEW COMPLETION**
0 No Interview
1 First phone call
2 Subsequent phone call
3 First mailing
4 Subsequent mailing
5 First visit
6 Subsequent visit
7 Other _____
9 Unknown

	Inj. No.	Body Region	Aspect	Lesion	System/ Organ	AIS Severity	Injury Source	ICDA Rating
43-53	1	__	__	__	__	__	__ __	__ __ __.__
54-64	2	__	__	__	__	__	__ __	__ __ __.__
65-75	3	__	__	__	__	__	__ __	__ __ __.__

USE WITH AIS CODES:
8 = Inj. Sev. Unk.
9 = Unk. if Inj.

76 OVERALL AIS __ 77-78 ISS __ __

NATIONAL CRASH SEVERITY STUDY: COLLISION SEVERITY

ACCIDENT IDENTIFICATION

1	___	UPDATE NUMBER
2	___	TEAM
3	___	YEAR
4-5	___ ___	MONTH
6-7	___ ___	DAY
8-10	___ ___ ___	SEQUENCE
11-13	___ ___ ___	CARD NUMBER

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VEHICLE NUMBER ___ (14)

IMPACT WITH VEHICLE NO. ___ (15)

IMPACT NUMBER ___ (16)

IMPACT SPEED (MPH) ___ (17) ___ (18)

DATA SOURCE (INPUT)		DELTA "V" MPH TOTAL			LONG.			LATERAL		
Trajectory & Detailed Damge	1									
Trajectory & CDC Only	2	(19)	(20)	(21)	+ - (22)	(23)	(24)	+ - (25)	(26)	(27)
Detailed Damage Only	3									
CDC Only	4				+			+		
Insufficient Data	9	(28)	(29)	(30)	+ - (31)	(32)	(33)	+ - (34)	(35)	(36)

RELATIVE VELOCITY: Longitudinal + - (37) (38) (39) (40) MPH

Lateral + - (41) (42) (43) (44) MPH

NOTE: Use Codes 1, 2 or 9 only in Column 19, and Codes 3, 4 or 9 only in Column 28.

VEHICLE NUMBER ___ (45)

IMPACT WITH VEHICLE NO. ___ (46)

IMPACT NO. ___ (47)

IMPACT SPEED (MPH) ___ (48) ___ (49)

DATA SOURCE (INPUT)		DELTA "V" MPH TOTAL			LONG.			LATERAL		
Trajectory & Detailed Damage	1									
Trajectory & CDC Only	2	(50)	(51)	(52)	+ - (53)	(54)	(55)	+ - (56)	(57)	(58)
Detailed Damage Only	3									
CDC Only	4				+			+		
Insufficient Data	9	(59)	(60)	(61)	+ - (62)	(63)	(64)	+ - (65)	(66)	(67)

RELATIVE VELOCITY: Longitudinal + - (68) (69) (70) (71) MPH

Lateral + - (72) (73) (74) (75) MPH

NOTE: Use Codes 1, 2 or 9 only in Column 50, and Codes 3, 4 or 9 only in Column 59.

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DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

NATIONAL CRASH SEVERITY STUDY: CRASH PROGRAM SUMMARY

1 ACCIDENT IDENTIFICATION
- 1 UPDATE NUMBER ___
- 2 TEAM ___
- 3 YEAR ___
- 4-5 MONTH ___ ___
- 6-7 DAY ___ ___
- 8-10 SEQUENCE ___ ___ ___
- 11-13 CARD NUMBER ___ ___ ___

2 VEHICLE SIZE: #1___ #2___

3 CDC #1 ___ ___ ___ ___ ___ ___ ___
CDC #2 ___ ___ ___ ___ ___ ___ ___

4 WEIGHTS KNOWN
5 No - Go to 7
6 Yes - Wt. #1 ___ ___ ___ ___
Wt. #2 ___ ___ ___ ___

7 REST AND IMPACT POSITIONS KNOWN
8 No - Go to 34
9 Yes -
Veh. 1 X___ ___ ___.___
Y___ ___ ___.___
ψ___ ___ ___ ___
Veh. 2 X___ ___ ___.___
Y___ ___ ___.___
ψ___ ___ ___ ___

10 IMPACT POSITIONS
Veh. 1 X___ ___ ___.___
Y___ ___ ___.___
ψ___ ___ ___ ___
Veh. 2 X___ ___ ___.___
Y___ ___ ___.___
ψ___ ___ ___ ___

11 DID VEH. 1 SLIDE SIDEWAYS
12 No - Go to 16
13 Yes - Did rotation cease prior to final rest?
14 No - Go to 16
15 Yes - Location
X___ ___ ___.___
Y___ ___ ___.___
ψ___ ___ ___ ___

16 WAS VEH. 1 PATH CURVED?
17 No - Go to 19
18 Yes - Point on Path
X___ ___ ___.___
Y___ ___ ___.___

19 VEHICLE #1 ROTATED?
20 None- Go to 22
21 CW or CCW (circle one)
More than 360° Yes No (circle one)

22 DID VEH. 2 SLIDE SIDEWAYS?
23 No - Go to 25
24 Yes - Did rotation cease prior to final rest?
No - Go to 25
Yes - Location
X___ ___ ___.___
Y___ ___ ___.___
ψ___ ___ ___ ___

25 WAS VEH. 2 PATH CURVED?
26 No - Go to 28
27 Yes - Point on Path
X___ ___ ___.___
Y___ ___ ___.___

28 VEH. #2 ROTATED?
29 None - Go to 31
30 CW or CCW (circle one)
More than 360° Yes No (circle one)

31 COEFFICIENT OF FRICTION ___.___ ___

32 ROLLING RESISTANCE
33 1. Proportion Braking Each Wheel
Veh. 1 RF ___.___ ___
LF ___.___ ___
RR ___.___ ___
LR ___.___ ___
Veh. 2 RF ___.___ ___
LF ___.___ ___
RR ___.___ ___
LR ___.___ ___
OR
2. Longitudinal deceleration
Veh. 1 ___.___ ___
Veh. 2 ___.___ ___

34 ARE DAMAGE DIMENSIONS KNOWN?
35 No - Go to 37
36 Yes - Dimensions in Inches
Veh. 1 L ___ ___ ___ ___
C_1 ___ ___.___
C_2 ___ ___.___
C_3 ___ ___.___
C_4 ___ ___.___
C_5 ___ ___.___
C_6 ___ ___.___
D ± ___ ___ ___.___
Veh. 2 L ___ ___ ___.___
C_1 ___ ___.___
C_2 ___ ___.___
C_3 ___ ___.___
C_4 ___ ___.___
C_5 ___ ___.___
C_6 ___ ___.___
D ± ___ ___ ___.___

37 IMPROVED FORCE DIRECTIONS?
38 No - Program Completed
39 Yes - Angles from Straight
Veh. 1 ± ___ ___ ___ ___
Veh. 2 ± ___ ___ ___ ___

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APPENDIX B

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TABLE B-1

Group Three Case Review Summary

NCSS CASE NUMBER	HEIGHT STRIKING & HEIGHT STRUCK	IMPACT ANGLE & SOURCE ESTIMATED*	VEHICLE DAMAGE INDEX	DISTANCE C.G. TO DAMAGE CENTROID	DAMAGE LENGTH-"L"	FORCE DIRECTION & SOURCE ESTIMATED **	TEAM DELTA-V & METHOD COMPUTED***	SAL DELTA-V & METHOD OF COMPUTATION		EJECTED OCCUPANT SEAT LOCATION	GAIS NEAR SIDE OCCUPANT	HEAD AIS/C.C.	CHEST AIS/C.C.	ABDOMEN AIS/C.C.	OTHER AIS/C.C.	COMMENTS ON AIS	OTHER OCCUPANT AIS/C.C.	REMARKS
6712035	3300 / 4200	-60 / S	10LYEN2	21	100	-60 / V	24 / DD				3		3 / 02		P-2 / 15	fx ribs 8, 9, 10		
6712049	3300 / 3700	-80 / S	10LDEW3	-4	95	-60 / V	26 / DD				4	1 / 18			L-4 / 17			
6703026	4000 / 4500	-45 / S	10LZEW6	-3	60	-45 / F	24 / DD				2	2	2 / 2	1 / 2		fy rib 7	1	
6702060	3900 / 4300	-75 / F	10LYEW3	46	87	-65 / F	24 / T				1		1 / 19		Q-1		1 / LR	
5707033	3700 / 2300	-90 / F	11LYGW3	9	50	-20 / F	27 / DD&T				1				F-1 / 03			Severe coding errors - Case ΔV should be disregarged.
6704019	4300 / 2800	-78 / F	10LDEW3	4	136	-60 / V	31 / DD&T	22 / DD			4		3 / 15		P-2 / 15	6 Fx ribs Fx pelvis		Team "L" dimension too large. 96" is more realistic
6709039	4500 / 3600	-25 / F	10LPEW4		82	-45 / F	26 / DD	20 / DD			1		1 / 27		S-1 / 23		CF	PDOF's were edited by Q.C. but the reconstruction had been performed by the old ones.
6709087	3400 / 3900		10LPEW3		97	-60 / V	24 / DD	19 / DD			3	1 / 23	3 / 15		S-1 / 15			Poor quality data: "L", "D", and weights were mixed up on vehicle & summary forms.
6709104	4800 / 3000	-90 / P	10LYEW4		129	-45 / F	31 / DD	25 / DD		driver	3		3		S-2			PDOF & "L" dimension edited by Q.C. reconstruction performed with old values
6711005	3800 / 4100	-77 / F	10LYEW4		112	-45 / F	26 / DD&T				3	1 / 23	3 / 15			multiple fx ribs	C-2 / RF	
6711014	4500 / 2300	-90 / F	10LYEW4	0	142	-75 / F	47 / DD	23 / DD			1	1 / 23			T-1 / 02			PDOF & "L" dimension edited by Q.C. reconstruction performed with old values
6801038	3900 / 4000	-70 / F	10LDEW3		140	-75 / F	24 / DD&T				2	2 / 18			P-2 / 17	fx pelvis	H-1 / RF	
6709012	4600 / 3000	-90 / F	10LYEW4	53	98	-60 / V	26 / DD&T				1	1 / 02				mild concussion		
3704044	4000 / 3400	-113 / F	08LZAW3	-20	96	135 / F	35 / 17 / T / DD	14 / DD			3	1	3 / 17			7 fx ribs		large descrepnency in ΔV's by Trajectory and damage methods due to pre-impact skidding.

* S-ESTIMATED FROM TEAM SKETCH
F-STATED ON TEAM DATA FORM
P-ESTIMATED FROM POLICE SKETCH
** V-VEHICLE DAMAGE INDEX
F-TEAM DATA FORM
*** DD-DETAIL DAMAGE METHOD
T-TRAJECTORY
DD+T-DETAIL DAMAGE PLUS TRAJ.

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TABLE B-1 Continued

Group Three Case Review Summary

NCSS CASE NUMBER	HEIGHT STRIKING & HEIGHT STRUCK	IMPACT ANGLE & SOURCE OBTAINED*	VEHICLE DAMAGE INDEX	DISTANCE C.G. TO DAMAGE CENTROID	DAMAGE LENGTH-"L"	FORCE DIRECTION & SOURCE OBTAINED **	TEAM DELTA-V & METHOD COMPUTED***	SRL DELTA-V & METHOD OF COMPUTATION	EJECTED OCCUPANT SEAT LOCATION	GRIS NEAR SIDE OCCUPANT	HEAD AIS/C.C.	CHEST AIS/C.C.	ABDOMEN AIS/C.C.	OTHER AIS/C.C.	COMMENTS ON AIS	OTHER OCCUPANT AIS/C.C.	REMARKS
5710030	3400 2000	-30 S	10LYEW7	0	30	-60 V	27 DD	35 DD		6	6 32	3 02		T-2 15	fx neck, fx femer, internal bleeding		"L" dimension edited by Q.C. Reconstruction had been performed with old value

* S-ESTIMATED FROM TEAM SKETCH
F-STATED ON TEAM DATA FORM
P-ESTIMATED FROM POLICE SKETCH
** V-VEHICLE DAMAGE INDEX
F-TEAM DATA FORM
*** DD-DETAIL DAMAGE METHOD
T-TRAJECTORY
DD+T-DETAIL DAMAGE PLUS TRAJ.

TABLE B-1 GROUP THREE CASE REVIEW SUMMARY

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TABLE B-2

Group Eight Case Review Summary

NCSS CASE NUMBER	Veh Strikng & Veh Struck	Impact Angle & Source Identified	Vehicle Damage Index	Distance C.G. to Damage Centroid	Damage Length-CU	Force Direction & Source Identified	Total Delta-V & Method Computed	Net Delta-V & Method of Computed	Ejected Occupant Seat Location	Child Seat Disc Occupant	Head Dis/C.C.	Chest Dis/C.C.	Abdomen Dis/C.C.	Other Dis/C.C.	Comments on Dis	Other Occupant Dis/C.C.	REMARKS
704086	39CO Bank	-90 S	11LDEW3	0	203	-20 F	30 DD	30-50 DD4T		5	5 8	3 2	2 1				Side Swipe bank-Common velocity assumption of Crash II may have been violated. Impact mode Critic.
710010	3560 Pole	-40 F	11LYAW4	15	30	-40 F	18 DD	18-25 DD4T		4	2 1			L-4 1	fx femur fx tibia		Question that femur open fracture is Life threatening. Trajectory strongly influenced reconstruction
708036	25CO 4100	-90 S	11LZEW2	-41	95	-66 F	18 DD	11 DD4T	driver	4				L-4 44	fx femur fx tibia		doubtful that common velocity was achieved
83008	29CO 7999	-30 S	11LYAW4	11	103	-30 F	23 DD	38 DD		3		5 18	5 02				the truck and car ΔV's were reversed on the computer and on the summary report.
708022	27CO 4200	-80 S	07LDEW3	-27	135	-170 F	36 DD4T			5		5 02	4 17				
710045	2100 3100	-45 S	11LZEW4	-13	63	-45 F	18 29 DD 1	28 DD4T		6	4 99			6 99			PDOF was edited to 11 o'clock by D.C.
705005	33CO Guard rail	-90 S	10LPAW6	-16	60	-60 V	23 DD	28 DD	driver	6	4 46			6 46			Team crush, measurement in error
706034	39CO rail	-60 S	02RDAW5	0	176	-60 V	59 DD			5	5 99				multiple 5's = 5?		Computer VDI listed wrong (OORDAW5)
703006	33CO tree	-30 S	11LPAW3	4	75	-30 V	37 DD			5		5 02	5 17		multiple 5's = 5?		

* S-ESTIMATED FROM TEAM SKETCH
F-STATED ON TEAM DATA FORM
P-ESTIMATED FROM POLICE SKETCH

** V-VEHICLE DAMAGE INDEX
F-TEAM DATA FORM

*** DD-DETAIL DAMAGE METHOD
T-TRAJECTORY
DD4T-DETAIL DAMAGE PLUS TRAJ.

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TABLE B-3

Group Four Case Review Summary

NCSS CASE NUMBER	Delta V Statistics & Delta V Source	Impact Angle & Source Definition	Vehicle Damage Index	Distance C.G. to Damage Centroid	Damage Length-Ft	Force Direction & Source Defined on	Term Delta-V & Method Computed	Sec. Delta-V & Method of Computation	Ejected Occupant Seat Location	Bus Seat Belt Use Occupant	Bus Rel/C.C.	Chart Rel/C.C.	Diagram Rel/C.C.	Other Rel/C.C.	Comments on Rel	Other Occupant Rel/C.C.	Remarks
1709016	— / 3400	80 / S	2RPAW5	-13	33	60 / V	25 / DD				1				F1 / 01		F1 / 01	occupant trajectory & veh. PDOF not consistent- reason?
3703017	3600 / 2900	90 / S	2RYEW3	-1.0	94	60 / V	27 / DD	22-28 / DD			2				O2 / 99		F1 / 02	ΔV edited from 32 to 22 after SRL req. PDOF/OCC. C.C. mis-match
4709046																		Frontal impact. Should not be in Group 4.
5802026	4800 / 3000	95 / F	2RYEW3	15	76	70 / F	20 / DD	18 / DD			1	1 / 34		1 / 15	N1 / 0		S2 / 02	Team used wrong damage reference line - minor change
6709100	2300 / 4000	90 / F	2RYEW3	0	108	45 / F	17 / DD				0						0	Team original ΔV was 25 edited to 17. Seems ok.
1712033	3400 / 3600	90 / S	2RZEW3	-33	37	60 / V	6 / DD				3		3 / 15			No hospital		ΔV may be around 10 mph. Rear axle impact - little crush.
6707007	4500 / 4000	84 / F	2RZEW3	-53	88	50 / F	16 / DD			R.F.	6				N4 / 40	Injury maybe resulted from ground		Team ΔV was 13, edited recently to 16. Appears ok.
1702036	4700 / 2300	90 / S	2RYEW3	14	53	120 / V	17 / DD				3		52 / 18		P3 / 20		C1 / 18	ΔV was edited from 11 to 17 after SRL Requested.

* S-ESTIMATED FROM TERM SKETCH
F-STATED ON TERM DATA FORM
P-ESTIMATED FROM POLICE SKETCH
** V-VEHICLE DAMAGE INDEX
F-TERM DATA FORM
*** DD-DETAIL DAMAGE METHOD
T-TRAJECTORY
DD+T-DETAIL DAMAGE PLUS TRAJ.

TABLE B-3 GROUP FOUR CASE REVIEW SUMMARY

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Case Number 5707033

This case was reconstructed both by trajectory and damage methods. The Δv computed for the struck vehicle by the damage method was 30 mph and by the trajectory method was 27 mph.

The striking vehicle was not found by the investigating team, so its damage measurements were not documented and no Vehicle Damage Index (VDI) could properly be assigned. It appears that the team "invented" a VDSI to use for their damage method reconstruction. The Quality Control Contractor noted the error and crossed out the VDI on the summary sheet, but he did not eliminate the damage only reconstruction obtained using the VDI.

The scene data sketch showed large spin-out rotation and small translation. In their trajectory reconstruction they answered "no" to any rotation questions. The Δv seems very high based on laboratory test results. In the absence of better or more information the Δv should be disregarded and dropped from the computer file.

Case Number 6704019

This case was reconstructed using both the trajectory and damage methods. The Δv was found to be around 30 mph using each method.

The amount of direct contact damage seems to be excessive when compared with the slides (only one view of each car). Also, the crush measurements appear to have been entered from front to rear instead of rear to front. The case was reconstructed at SRL using the damage method and using the edited VDI as PDOF for vehicle 1. The damage length was reduced from 136 inches to 96 inches. The Δv was found to be 22 mph.

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The impact angle that the team coded in their trajectory reconstruction was 88°. The angle on the scene sketch was about 110° to 115°. Quality Control noted a question in the VDI force direction based on this sketch. A trajectory reconstruction using an impact angle of 110_{o} was done at SRL, and the resulting Δv was 26 mph. Since the scene data are unclear, the damage result of 22 mph is believed to be more accurate.

Case Number 6709039

This case was reconstructed by the team using damage data. The team selected force directions for the reconstruction were 15° and 45°, respectively. Each lie between two clock directions of force. This indicates a lack of confidence in their ability to select a force direction. Although only one view of the striking vehicle is shown in the slides, the crush depths coded for V_1 seem to be excessive.

The case was reconstructed at SRL using the Quality Control edited force directions and the damage analysis Δv was 20 mph.

The scene data collected by the team was used for a trajectory reconstruction. the solution to the data as coded was high. Pre-crash skidding was shown on the scene sketch which would affect the outcome. The trajectory reconstruction is not considered valid.

Case Number 6709087

This case was reconstructed by the team using the damage routine. The Δv was calculated as 24.

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In editing the case Quality Control noted that all the VDI's were coded wrong. The vehicle codes are inter-changed throughout the forms. The length of damage from direct contact is too large. The "D" parameter for the struck vehicle was coded as 35 inches even though it was a direct door impact. The "L" dimension was coded as 143 inches for a door that is about 36 inches wide. The vehicle weights and corresponding damage measurements are not consistent. The case should have been returned.

Case Number 6709104

This case was reconstructed using damage information. The length of damage due to direct contact was coded as 129 inches (larger than the wheel base) which appeared excessive. Again, the team used force directions of 15° and 45° for the two vehicles so it would match VDI's of either sector.

The case was reconstructed at SRL using the edited VDI's as force directions and a small damage length and the Δv found to be around 25.

Case Number 6711014

This case was reconstructed using damage information. The Δv was recorded as 47 mph.

The team chose force directions of $+75^{o}$ for vehicle 1 and -75° for vehicle 2. The fact that in nearly every case they chose a force direction that lies at a midpoint between 2 clock directions of force demonstrates that they are not confident in their VDI force directions. Quality Control edited the VDI's but did not alter the reconstruction.

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The length of damage from direct contact was coded as 142 inches with no midpoint offset and yet the VDI coded a "y" damage region. Also, this was not corrected by Quality Control.

A reconstruction at SRL estimated the Δv to be about 23 mph.

Case Number 3704044

This case was reconstructed with both trajectory and damage methods. The trajectory reconstruction resulted in a Δv of 35 mph while the damage reconstruction resulted in a Δv of 17 mph. The investigating team noted that the disagreement could be due to the continued engagement of the two vehicles during the early trajectory.

Analysis of the case showed that clockwise pre-impact skidding occurred. In addition, the clock force direction on the struck vehicle was not consistent with the relative velocity of the vehicles.

Cases with pre-impact rotation are outside of the original assumptions of the model. However, reasonable agreement between the two methods of reconstruction was reached by correctng the force angle and adding rotation to the struck vehicle to artifically account for the clockwise skidding. The Δv for each method was then about 14 mph.

Case Number 5710030

This case was reconstructed using the damage measurements. The struck vehicle, a Spitfire, was severly damaged. The Δv was coded as 27 mph.

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The striking vehicle was a Ford Granada. The damage was coded as 70 inches of direct contact to the front with 70 inches of contact length. At the same time only 30 inches was coded for the side of the Spitfire. It is believed that the contact length on the Spitfire would be, at least, 70 inches and possibly more. Also, the 12 o'clock force direction on the Ford is unlikely since the scene sketch shows the impact to be angled with a small velocity for the struck vehicle.

The Δv with 70 inches of contact and a 01 o'clock force direction is 35 mph.

Case Number 1709016

This case was requested for review because of the high Δv (25 mph) and the minor injury level (AIS 1) coded on the computer.

The case vehicle was a Dodge Coronet which was out of control sliding broadside into a utility pole. The crush was centered at the B-pillar with a maximum extent of 32.5 in. The PDOF was coded as 2 o'clock, but may have been closer to 3 1'clock.

Both occupants had minor injuries from contact with the dash board. The reason for the discrepancy in vehicle PDOF and occupant contact points is not known. An analysis with the SMAC model was attempted to see if vehicle rotation could have accounted for the contact points. The SMAC reconstruction of the pole impact was not satisfactory. It is postulated that the occupants were thrown forward and out of position by pre-crash skidding and were against the dash at impact.

Case Number 3703017

The case was reviewed because of the high Δv (32 mph) coded on the computer and the moderate injury (AIS 2) coded for the RF passenger.

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The case review showed that further editing had been done since the recent computer listing was received by the SRL. The team reported Δv's of 29 mph and 332 mph have been recomputed as 24 mph and 27 mph respectively. Other minor edits were noted.

Inconsistencies noted were as follows:

1. The scene sketch indicated that vehicle 2 rolled approximately 20 feet straight forward after impact, but the reconstruction computed a 32 mph pure lateral Δv.

2. RF passenger contacts were noted to the windshield and dashboard, but not on the door or A-pillar area.

3. The case vehicle was listed as weighing 2900 pounds with 600 pounds cargo, yet it was classified as an intermediate.

Case Number 4709046

This case was a frontal impact and should not have been included in Group 4.

Case Number 5802026

This case was reviewed because of the high Δv (20 mph) and low injury level (AIS 1) for the RF occupant. The case involved an impact between a Ford Country Sedan wagon and a Ford Maverick. There appeared to be full sill engagement. The reference line established by the team is shown to be at about the underformed projection of the vehicle on the ground, yet the crush was at the sill area, which is tucked under from the upper sheet metal. It is believed that this leads to slightly larger crush damage dimensions.

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Case Number 6709100

This case was requested for review because of the high Δv (25 mph) and minor injury (AIS 1) coded on the computer. It appears that this case was edited and the computer file updated during February, 1979. The side impacted vehicle Δv is now coded as 17 mph. The SRL has reviewed the update and is in agreement with the change.

Case Number 1712033

This case was requested for review because of the low Δv (6 mph) and serious injury (AIS 3) coded on the computer. The impact was in the rear compartment and wheel-well area. It is difficult to account for the difference in damage measurements caused by the rear axle. Judging from the front of V-1, the Δv was not more than 10 mph.

A comparison of the injury information in this case with cases 3703017, 5802026, and 6709100 reveals a weakness in injury correlations among accidents. In the three accidents cited, no X-rays were taken and the injury levels were coded as AIS 1 or 2, while the occupants spent time in the hospital. In the present case, the occupant was not admitted into the hospital, but X-rays were taken which revealed 2 rib fractures.

Case Number 6707007

This case was requested for review because of the low Δv (13 mph) and high injury level (AIS 6) coded on the computer listing, dated February 26, 1979. The March computer dump showed that the case has recently been updated and the case vehicle Δv was now coded as 16 mph.

The fatally injured occupant was completely ejected and had a broken neck. No correlation to impact Δv should be expected.

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APPENDIX C

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Case Number 1711025

This case was selected for review because of the higher Δv (24 mph) and the unknown injury level (AIS 9) coded on computer. The case involved a Peugeot impacting the passenger side of a Volkswagon Beetle. The driver reportedly hit the passenger side windshield and bruised both knees. The impacting vehicle damage was not recorded due to repaired sheetmetal. From a study of the slides of the Volkswagon, the SRL opines that a lower Δv was achieved in this impact. Also, the quality control manager edited the VDI of vehicle one but did not change the computer simulation. Thus, the SRL performed a new reconstruction based on the edited VDI's and photographic review and obtained a new Δv of 10 mph. The file should be changed to reflect this speed change.

NCSS Case Study 2707019

This NCSS case was selected because of the higher AIS (5) and the disagreement between the trajectory speed change (19 mph) and the damage speed change (11 mph). The case involved a full size Ford impacting a pole in front of the left front wheel. The concentrated impact area with the pole and the resulting violent rotation of the vehicle after impact are in the opinion of the SRL and based on crush, indicative of a 20 mph impact. Thus, the SRL opines that the file should be edited to have a Δv of 19 mph based on the trajectory and damage results. Also, the injury is a result of complete ejection of the driver from the car during the pole impact and rotation.

NCSS Case Number 2712024

This case was selected for review because of the longitudinal component (7 mph) on the impact. The case involved an Oldsmobile

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being struck by a Maverick. The team had recorded a 7 mph longitudinal component of velocity with a PDOF of 09LYEN2. The quality control manager caught the error and edited the results to be a 3 mph lateral component and 0 mph longitudinal. The SRL reconstruction agreed with the edited analysis.

Case Number 3708036

This case was selected for review because of the higher Δv (22 mph) and the lower AIS (1). This case involved two intermediate vehicles -- a Chevrolet Monte Carlo and an Oldsmobile Cutlass. A careful review of the team photographs showed side damage at locations F and B on the Chevrolet's left side and the occupant compartment was undamaged. Furthermore, the large force due to the impact was concentrated on the left side-front over the wheel and thus was not as severe to the occupant had it been between the A-C pillars. The SRL performed a CRASH II and SMAC run and opines that this accident is correctly presented and the AIS levels were properly recorded.

NCSS Case Study 6706037

This case was selected for review because of the large longitudinal component of velocity (6 mph). The accident involved a Chevrolet impacting with a pole. Prior to impact, the vehicle made several 360^0 rotations with added components of velocity. Quality Control edited the PDOF without changing the reconstruction. The SRL performed the edited reconstruction and obtained ΔV's of -7.4 mph lateral and -5.7 mph longitudinal. The reconstruction Δv of 9.3 mph for the trajectory and detailed damage compared favorably with the 8.0 mph Δv for detailed damage only. The corrected Δv is consistent with the low occupant injury levels and the damage.

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NCSS Case Study 6711078

This case was requested for examination because of the unknown AIS. The accident involved a Chevrolet and Ford intersection collision. The file review confirmed no data on injury level of persons involved. Examination of the reconstruction revealed that Quality Control edited the damage index but did not perform the reconstruction. Also, the length of vehicle contact was high and the Δv appeared excessive. The SRL performed the edited reconstruction and Δv was lowered by only 1 mph from 18 mph. Thus, this file is correct.

NCSS Case Study 6706012

This case was selected for review because of the large longitudinal component of velocity (16 mph) and lower lateral component. The vehicles (an Oldsmobile and Ford) impacted at an intersection. The team had no photographs of the Ford and thus no method was available to verify the damage. Additionally, no skid marks were visible in the scene slides. Results of the team are questionable and Quality Control also expressed concern. The SRL reconstructed the accident and opines that the Δv should be based on the detailed damage only and not the trajectory simulation. This resulted in a 10 mph lateral and 6 mph longitudinal ΔV.

NCSS Case Study 6709010

This case was selected for review because of the unknown injury level of the driver. The case involved a Chevrolet (compact) impacting a Ford. The team evaluation was an AIS 3 while Quality Control changed this to AIS 8. HSRI's evaluation was that the maximum AIS was a level 3. The SRL reconstruction revealed that reconstruction of the data was correct.

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NCSS Case Number 7702005

This case was selected because of the lateral Δv of 15 mph and the unknown AIS. The case involved a Cadallic Seville impacting the left side between the A and C pillar of a Pontiac Firebird. The request for review was because of the unknown AIS level. The Quality Control officer edited the AIS from the team value of 2 to an injury severity level unknown.

The SRL review of the team data would support a value of AIS 2. The poor slide quality did not permit the SRL to reconstruct this accident and thus relies on the reconstruction results as consistant with the observable damage.

Case Number 1701008

This case was reviewed because of the high AIS level, (4) and lower Δv (12 mph). The case involved two full size vehicles -- a Buick and Chrysler. The struck vehicle was never measured (inspected) and no measurements obtained for the reported detailed damage reconstruction. It is suggested that the Δv be dropped from the file due to insufficient data.

Case Number 1777039

This case was a single vehicle accident involving a MGA which lost control on a curve. It was reviewed because of the high AIS (5) and low Δv (7 mph). The accident involved impacting two separate trees resulting in the ejection of the driver. The driver was found pinned between the tree and the vehicle and this ejection explains the higher AIS (5) for the low Δv (7 mph).

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Case Number 1783049

This case was examined because of the high Δv (29 mph) and low injury level (AIS 1). The case involved a Ford Maverick and Chevrolet Vega with impact into the passenger side of the Vega. The driver of the Vega suffered minimum contact due to use of the lap belt. The Δv and injury appear to be accurately reported.

Case Number 2705025

This case was selected due to the high Δv (37 mph) and unknown AIS. The case involved a Lincoln Continental and an Olds Cutlass which traveled over rough terrain prior to rest. The HSRI edited the Δv to 14 mph due to the wrong impact codings and weight of one vehicle by the team. The 14 mph Δv appears to be accurate. Finally, SRL opines that an AIS of 1 could have been recorded, and that the file Δv should be updated to the 14 mph ΔV.

Case Number 3770416

This case was selected to review because of the injury information AIS 3 for the large Δv (22 mph). The case was a single vehicle accident (Chevrolet) with the left side impacting a utility pole. Because of the narrow object impacted, the damage was concentrated between the A and B pillar. The SRL review of the Δv found no errors and this case should be kept in the file.

Case Number 3707074

This case was selected for the low Δv (3 mph) and the high AIS of 3. The accident was a single vehicle that flipped over once after hitting a guard rail before impact with a tree. The occupant was ejected during roll over and this accounts for the high AIS reading. SRL opines this is a unique side impact accident and due to driver ejection should not be used in injury correlation with ΔV.

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Case Number 4706006

This case was selected for the high Δv (27 mph) and the low injury level (AIS 2). The case involved a Volkswagen "Beetle" which impacted into a Cadillac deVille. The team had incorrectly reversed the vehicle numbers on the summary form. The side struck vehicle was the Cadillac which had a Δv of 10 mph and is consistant with the injuries sustained. This case should be corrected on the file.

Case Number 4706015

This case was selected for review based on a high Δv (23 mph) and a low AIS 2. The case involved a single vehicle accident (Chevrolet Chevelle) that left the road surface and traversed over several stumps prior to impact with a tree on the passenger side. No restraint system was used by the driver. The Δv is not certain due to severe undercarriage deformation as a result of the objects struck prior to impact with the tree by the vehicle, thus, allowing for driver "ride down". Finally, because of undercarriage damage prior to final side impact, the integrity of the vehicle was compromised. SRL suggests that the Δv be dropped from the file.

Case Number 7712036

This case was selected for review due to the high Δv (19 mph) and unknown AIS. The accident involved a Buick Wildcat and a Chevrolet Chevelle. The damage on the struck vehicle, in the opinion of SRL, is not consistant with a 20 mph ΔV.

Unfortunately, the poor slide quality does not allow SRL to perform a detailed damage reconstruction. The case Δv should be dropped from the file.

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Case Number 7705008

This case was requested for the review because of the higher Δv (30 mph) and the injury level (AIS 5). This was a single vehicle accident in which a Pontiac Grand Prix was making a left hand turn and collided with a building on the vehicle right side. The injury causations were from the hood making contact with the occupants which is questionable due to the reported 3 o'clock force direction impact. However, SRL could determine no errors in the reconstruction.

Case Number 5702007

This case was requested for review because of the higher Δv (17 mph) and the unknown injury level (AIS 9) coded on the computer.

The case involved a Volkswagen Beetle impacting a chevrolet Chevelle. The team Δv of 17 mph has been edited by Quality Control to 10 mph which is compatible with the damage of 11 inches. The case Δv should be corrected on the file.

Case Number 7705009

This case was requested for review because of the higher Δv (25 mph) and the unknown injury level. Also, the HSRI reviewed this case. Specifically, it is a single vehicle accident that resulted in side impact just behind the B pillar with a light pole on the passenger side. The driver was not interviewed but was reported in a coma after the accident with facial lacerations and a fractured pelvis from (reported) contact with left door and frame. The review by HSRI estimated an AIS of 3 for the head, 2 for the pelvis, and 1 for the face. The reconstruction appears to be accurate.

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Case Number 4702045

This case was selected for review because of the directions of the velocity components and higher Δv (16 mph) and unknown injury severity level (AIS 8) coded on the computer. The accident involved a single vehicle (Ford) that lost control on an ice covered road and slid into the guard rail. Impact on the right front corner is a sideswipe with bumper override. The Δv is higher than the damage indicates due to rotation and sideswipe as noted by the Quality Control reviewer. Finally, the accident involved two impacts and the vehicle damage index have been reversed in the computer output. These errors should be corrected on the file.

Case Number 5705050

This accident was requested for review because of the higher Δv (20 mph) and the low injury level (AIS 1). This accident was a three vehicle intersection collision in which a Pontiac was impacted on both sides from two different vehicles. The young driver suffered facial lacerations and some hip contusions. Additionally, the driver was unrestrained and was actually a far side occupant (the first impact threw the driver out of position) during the second and most severe impact. This could lead to errors in correlating near side occupant impacts with ΔV.

Case Number 6202099

This case was selected for review because of the high Δv (36 mph) and the unknown injury level (AIS 8). The accident involved a Chevrolet Chevelle that impacted with a utility pole on the right side between B and C pillar. The passenger (near side occupant) was ejected and the driver was trapped with both requiring a hospital

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stay. The team made an error in damage measurements which affects the Δv estimate. HSRI's review estimated a new Δv of 14 mph but offered no explanation as to method or reason. SRL agrees with the lower Δv based on the photographic study. Since the nearside occupant was ejected, care should be exercised in the use of the injury and Δv correlation. The computer file and hard copy should be updated to the 14 mph ΔV.

Case Number 7701011

This case was requested for examination because of the higher Δv (27 mph) and the unknown injury level (AIS 8) of the occupants. The case involved a single vehicle which impacted a pole. The occupant of the vehicle reportedly suffered facial lacerations and a depressed and fractured skull. The injury appears to be, in the opinion of SRL, an AIS of at least 3. However, Quality Control reviewed the file and changed the AIS to 8 because of the unknown head severity injury. SRL opines that the AIS should be at least 3. The reconstruction is correct.

Case Number 0178025

This case was selected for review because of the larger lateral component of velocity (12 mph) and the lower AIS of 2. The case involved two Chevrolets that impacted with a rollover of the struck vehicle. The results, as reported by the team and questioned by Quality Control, have the second impact resulting in a higher Δv than the first impact. This, in the opinion of SRL, is an impossibility based on the case review. Additionally, the reported impact is the second event during this accident. The case Δv should not be included in the file.

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Case Number 1711047

This case was requested for review because of the higher Δv (24 mph) and the unknown injury level (AIS 8). The case involved a single vehicle, a Chevrolet, that impacted a tree. The penetration and speed estimate are compatible with the reconstruction. The driver died from severe head injuries of an unknown injury level. The case appears to be accurate.

Case Number 1803031

This case was requested for review because of the results of a Δv of 7 mph and a lateral component of velocity of 10 mph. The overall AIS was 2. This case involved a Dodge and an Oldsmobile in an intersection collision. The team results were changed by Quality Control to a total Δv of 10 mph with a 10 mph lateral component of velocity. Based on this change, a subsequent editing, the case appears to be correct.

Case Number 2702022

This case was selected for review because of the higher Δv (26 mph) and the lower AIS (2). The case involved a small Ford impacting a large Oldsmobile. The far side impact allowed for driver "ride" down during crushing of the vehicle resulting in the lower AIS. SRL agrees with the reconstruction.

Case Number 4708042

This case was selected because of the longitudinal Δv reported while a pure lateral force direction was also reported. The total Δv was

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reported to be 18 mph and the injury unknown. This case involved three vehicles in an intersection collision with a full-size Ford, a Chevrolet Monza and a Chevrolet Vega. Quality Control noted errors in vehicle numbering and the damage index. The Δv was edited to a total of 11 mph with no longitudinal component. No injuries were recorded to the occupant as a result of the far side impact. SRL is in agreement with the Quality Control changes.

Case Number 6706038

This case was selected because of the large reported longitudinal component of velocity (-11 mph) which was inconsistent with the reported pure lateral force direction. The case involved two Fords (intermediate and full size). The reported team Δv was changed from a -11 mph longitudinal component to 0 mph because of the narrow impact area and the bumper override. This edited change in ΔV, to a total of 5 mph is consistent with the damage and is a pure side impact. The Δv file should be updated with the correct reconstruction.

NCSS Case Study 6708021

This case was selected for review because of the larger velocity component in the longitudinal direction (-8 mph) and smaller lateral component (5 mph). The case involved a Volkswagon (Bug) impacting a fullsize Ford. The team did not photograph the "Bug" which was reported as having a 23 mph ΔV, and the inspection of the Ford was after repairs. The Quality Control reviewer questioned the results since the reconstruction was based on damage estimates and edited the VDI from 11LFEW3 to 09LFEW2. The SRL reconstruction based on the above VDI had ΔV's of 12 mph and 5 mph for V_1 and V_2. This, opines SRL, is more consistant in light of the lack of injury to the unrestrained occupant of V_1.

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APPENDIX D

Relative Velocity Code

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```
10 DIM S[2],P[2],L[2],C[2],D[2,6],A[2,6]
20 DIM B[2,6],E[2],U[6],Z$[50],V$[7],W$[7]
30 DISP "RELATIVE VELOCITY CALCULATION"
40 WAIT 2000
50 DISP "ENTER TITLE  (MAX. 50 CHAR.)";
60 INPUT Z$
70 DISP "INPUT V1 AND V2 SIZE CATEGORIES"
80 WAIT 1000
90 DISP "1=MIN 2=SUB 3=COM 4=INT 5=FUL 6=LAR";
100 INPUT S[1],S[2]
110 DISP "INPUT V1 DAMAGE INDEX";
120 INPUT V$
130 DISP "INPUT V2 DAMAGE INDEX";
140 INPUT W$
150 IF V$[3,3]="F" THEN 180
160 P[1]=2
170 GOTO 190
180 P[1]=1
190 IF W$[3,3]="F" THEN 220
200 P[2]=2
210 GOTO 230
220 P[2]=1
230 DISP "EXACT PDOF KNOWN 1=Y 2=N";
240 INPUT Q1
250 IF Q1=2 THEN 310
260 DISP "ENTER V1 PDOF";
270 INPUT F1
280 DISP "ENTER V2 PDOF";
290 INPUT F2
300 GOTO 330
310 F1=VAL(V$[1,2])*30
320 F2=VAL(W$[1,2])*30
330 IF F1 >= 180 THEN 350
340 GOTO 360
350 F1=360-F1
360 IF F2 >= 180 THEN 380
370 GOTO 390
380 F2=360-F2
390 IF P[1]=2 THEN 420
400 F1=F1*PI/180
410 GOTO 430
420 F1=(90-F1)*PI/180
430 IF P[2]=2 THEN 460
440 F2=F2*PI/180
450 GOTO 470
```

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```
460 F2=(90-F2)*PI/180
470 K1=1+TAN(F1)*TAN(F1)
480 K2=1+TAN(F2)*TAN(F2)
490 DISP "ACTUAL WEIGHTS KNOWN? 1=Y 2=N";
500 INPUT W
510 IF W=2 THEN 560
520 DISP "INPUT V1 WT.";
530 INPUT W1
540 DISP "INPUT V2 WT.";
550 INPUT W2
560 DISP "INPUT V1,V2 DAMAGE LENGTHS (IN.)";
570 INPUT L[1],L[2]
580 DISP "INPUT NO. V1 DAM. PTS.(2,4,OR6)";
590 INPUT C[1]
600 GOTO C[1]/2 OF 610,640,670
610 DISP "INPUT C1 AND C2";
620 INPUT D[1,1],D[1,2]
630 GOTO 690
640 DISP "INPUT C1 THROUGH C4";
650 INPUT D[1,1],D[1,2],D[1,3],D[1,4]
660 GOTO 690
670 DISP "INPUT C1 THROUGH C6";
680 INPUT D[1,1],D[1,2],D[1,3],D[1,4],D[1,5],D[1,6]
690 DISP "INPUT NO. V2 DAM PTS.(2,4,OR6)";
700 INPUT C[2]
710 DISP "INPUT C1 THROUGH C";C[2];
720 GOTO C[2]/2 OF 730,750,770
730 INPUT D[2,1],D[2,2]
740 GOTO 780
750 INPUT D[2,1],D[2,2],D[2,3],D[2,4]
760 GOTO 780
770 INPUT D[2,1],D[2,2],D[2,3],D[2,4],D[2,5],D[2,6]
780 DISP "END OF USER INPUT  THANK YOU"
790 WAIT 4000
800 FOR I=1 TO 2
810 FOR J=1 TO 6
820 READ A[I,J]
830 NEXT J
840 NEXT I
850 FOR I=1 TO 2
860 FOR J=1 TO 6
870 READ B[I,J]
880 NEXT J
890 NEXT I
900 FOR I=1 TO 2
910 FOR J=1 TO 6
920 READ G[I,J]
```

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```
930 NEXT J
940 NEXT I
950 FOR I=1 TO 2
960 GOTO C[I]/2 OF 970,1010,1080
970 T1=A[P[I],S[I]]*(D[I,1]+D[I,2])/2
980 T2=B[P[I],S[I]]*(D[I,1]*D[I,1]+D[I,1]*D[I,2]+D[I,2]*D[I,2])/6
990 E[I]=L[I]*(T1+T2+G[P[I],S[I]])
1000 GOTO 1160
1010 T1=A[P[I],S[I]]*(D[I,1]+2*D[I,2]+2*D[I,3]+D[I,4])/2
1020 T3=D[I,3]*D[I,3]
1030 T4=D[I,4]*D[I,4]
1040 T5=D[I,1]*D[I,2]+D[I,2]*D[I,3]+D[I,3]*D[I,4]
1050 T2=B[P[I],S[I]]*(D[I,1]*D[I,1]+2*D[I,2]*D[I,2]+2*T3+T4+T5)/6
1060 E[I]=(L[I]/3)*(T1+T2+3*G[P[I],S[I]])
1070 GOTO 1160
1080 T1=A[P[I],S[I]]*(D[I,1]+2*D[I,2]+2*D[I,3]+2*D[I,4]+2*D[I,5]+D[I,6])/2
1090 T3=D[I,3]*D[I,3]
1100 T4=D[I,4]*D[I,4]
1110 T5=D[I,5]*D[I,5]
1120 T6=D[I,6]*D[I,6]
1130 T7=D[I,1]*D[I,2]+D[I,2]*D[I,3]+D[I,3]*D[I,4]+D[I,4]*D[I,5]+D[I,5]*D[I,6]
1140 T2=B[P[I],S[I]]*(D[I,1]*D[I,1]+2*D[I,2]*D[I,2]+2*T3+2*T4+2*T5+T6+T7)/6
1150 E[I]=(L[I]/5)*(T1+T2+0.5*G[P[I],S[I]])
1160 NEXT I
1170 IF W=1 THEN 1230
1180 FOR I=1 TO 6
1190 READ U[I]
1200 NEXT I
1210 W1=U[S[1]]
1220 W2=U[S[2]]
1230 M1=(W1+300)/386.4
1240 M2=(W2+300)/386.4
1250 E[1]=E[1]*K1
1260 E[2]=E[2]*K2
1270 X1=(2*(E[1]+E[2])/(M1*(1+M1/M2)))^0.5
1280 X2=(2*(E[1]+E[2])/(M2*(1+M2/M1)))^0.5
1285 PRINT
1286 PRINT
1287 PRINT
1290 PRINT Z$
1292 PRINT
1293 PRINT
1300 PRINT "VEHICLE 1 SIZE CATEGORY IS";S[1]
1310 PRINT "VEHICLE 2 SIZE CATEGORY IS";S[2]
1320 PRINT "VEHICLE 1 DAMAGE INDEX=";V$
1330 PRINT "VEHICLE 2 DAMAGE INDEX=";W$
1340 PRINT "VEHICLE 1 WEIGHT=";W1;"LBS"
```

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```
1350 PRINT "VEHICLE 2 WEIGHT=";W2;"LBS"
1360 PRINT
1370 PRINT
1375 FIXED 1
1380 PRINT "ENERGY OF VEHICLE 1=";E[1]/12;"FT-LBS"
1390 PRINT "ENERGY OF VEHICLE 2=";E[2]/12;"FT-LBS"
1400 PRINT
1410 PRINT
1420 PRINT "VEHICLE 1 DELTA-V=";X1*(60/(88*12));"MPH"
1430 PRINT "VEHICLE 2 DELTA-V=";X2*(60/(88*12));"MPH"
1440 PRINT
1450 PRINT
1460 PRINT "RELATIVE VELOCITY =";(X1+X2)*(60/(88*12));"MPH"
1470 DATA 130.5,130.5,154.6,281.8,307.5,307.5
1480 DATA 82.21,82.21,111.8,43.72,49.19,49.19
1490 DATA 58.72,58.72,69.57,33.82,36.89,36.89
1500 DATA 42.76,42.76,58.16,47.23,53.13,53.13
1510 DATA 144.94,144.94,171.78,1174.3,1281.1,1281.1
1520 DATA 79 04,79.04,107.5,20.24,22.77,22.77
1530 DATA 1902,2753,3247,3947,4565,5009
1540 END
```